# Acta Genetica et Statistica Medica

In association with

Otto L. Mohr
Professor of Anatomy, Oslo

Tage Kemp
Professor of Human Genetics, Copenhagen

edited by:

Gunnar Dahlberg
Head of the State Institute of Human Genetics and Race Biology, Uppsala

Vol. II Supplementum II 1951

## CHANGES IN THE SIZE OF THE LOWER JAW ON ACCOUNT OF AGE AND LOSS OF TEETH

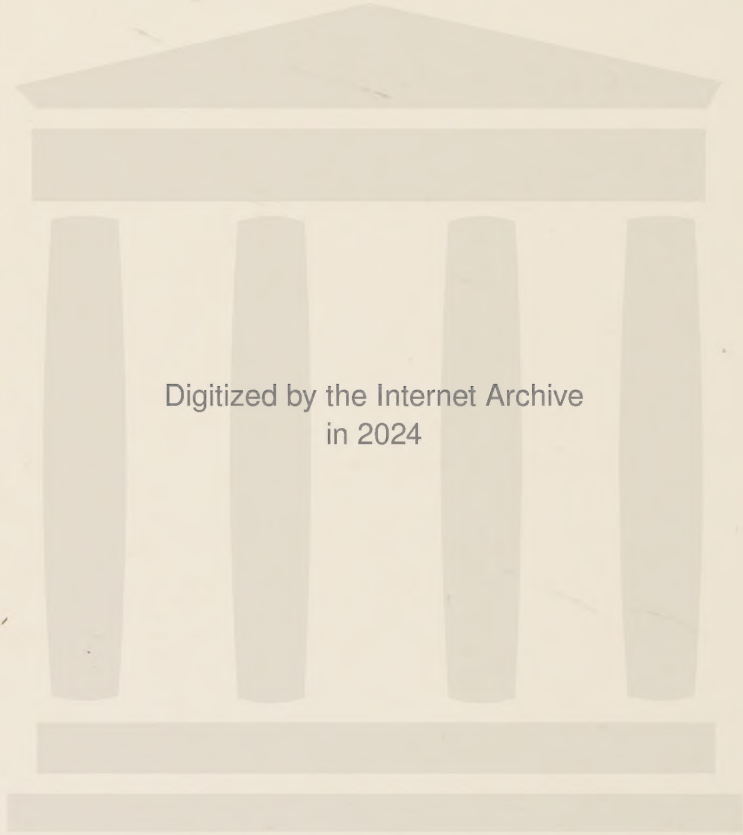
BY

*Pontus Lönberg*


BASEL (Switzerland) S. KARGER NEW YORK

## ERRATA

| | |
|---|---|
| P. 9, last line: | for "mandibes" read "mandibles". |
| P. 11, 1: | for "451" read "351". |
| P. 11, 8 from top: | for "200" read "100". |
| P. 16, 4: | for "pogonion" read "gnathion". |
| P. 17, 6: | for "secondary aperture" read "secondary aperture grid" |
| P. 21, 3: | for "7 cm" read "7 mm". |
| P. 24, 5: | for "laterally" read "laterally situated points. This point". |
| P. 31, 23: | for "sagittal" read "dorsofrontal". |
| P. 31, 26: | for "dorsofrontal" read "sagittal". |
| P. 31, 32: | for "left" read "right". |
| P. 41, 5: | for "jrw read "jaw". |
| P. 41, 6: | for "toothass" read "toothless". |
| P. 42, 29: | for "Corrected" . . . reveal" read "Corrected for geometric distortion the figures reveal". |
| P. 49, 2: | for "in term" read "in time". |
| P. 49, 2: | for "ramus" read "corpus". |
| P. 49, 17: | for "22.25 $\pm$ 0.85" read "2.25 $\pm$ 0.85". |
| P. 50, tab. 15, col. 7, 11: | for "17.71 read "11.71". |
| P. 50, tab. 15, col. 9, 6: | for "22.25" read "2.25". |
| P. 52, 7: | for "ramal" read "read "corpus". |
| P. 60, 12: | for "3.54 $\pm$ 0.01°" read "3.54 $\pm$ 1.01°". |
| P. 64, 12: | delete "ramus and". |
| P. 66, 20: | for "care" read "the cavity". |
| P. 68, text to fig. 32: | for "Oldepersons with teeth" read "Old persons without teeth". |
| P. 69, 34: | for "10°" read "7°" |
| P. 74, 4: | for "ramal" read "corpus". |
| P. 74: | Delete last sentence, beginning "A probable . . .". |



FROM THE ROYAL SCHOOL OF DENTISTRY, STOCKHOLM, DEPARTMENT OF
DENTAL ROENTGEN DIAGNOSTICS (HEAD: PROFESSOR GUSTAF HERULF)
AND THE STATE INSTITUTE OF HUMAN GENETICS AND RACE BIOLOGY,
UPSALA (HEAD: PROFESSOR GUNNAR DAHLBERG, M. D., LL. D.)

# CHANGES IN THE SIZE OF THE LOWER JAW ON ACCOUNT OF AGE AND LOSS OF TEETH

BY

PONTUS LÖNBERG

STOCKHOLM 1951

*Translated by:*

KLAS MAGNUS LINDSKOG

Esselte AB, Stockholm 1951

# Contens

# Preface

Atrophy of the tissues is one of the symptoms of old age; but also the skeletal framework changes — it becomes more brittle and fragile. The aim of the author is by means of measurements, — direct and on roentgenographs — to ascertain whether the aged show any changes in the size of the lower jaw. In so doing, and with similar technique, I also attempted to ascertain the effect of loss of teeth on the mandibular size. The study was carried out on a group of 351 men, of whom 151 were young (about 25 years) and 200 old (over 65 years). Half of each subgroup comprised persons without teeth and half included persons with complete or reasonably complete sets of teeth.

First and foremost I must express my deep gratitude to my chief, Professor Gustaf Herulf, for putting at my disposal all the facilities of the Department of Roentgen Diagnosis, for his courtesy in giving me the opportunity to perform the investigation, and for his constant willingness to let me have the benefit of his profound knowledge of roentgenological matters.

I next wish to warmly thank Professor Gunnar Dahlberg of the State Institute for Race Biology and Human Genetics, Uppsala, who suggested this investigation and also made available trained personnel for the statistical work. Last but not least I would express my obligation to him for giving me the privilege of consulting him on the often intricate problems that presented themselves from time to time.

I am indebted, too, to Doctor Seved Ribbing, M.D., Senior Physician, and Mr Arne Björk, Dr. Odont., Dental Surgeon, for giving me valuable technical information.

Mr Max Lundberg and Mmes Margit Henriksson and Anne-Marie Ryd-Blomquist, Dental Surgeons and Amanuenses at the State College of Dentistry, Stockholm, have given technical assistance and checked errors, and for that I heartily thank them.

Last but not least I wish to convey my gratitude to the Dean and Board of Teachers for being awarded a Post-Graduate Scholarship and for financial support from the State grant for the Promotion of Medical Research.

# Introduction

It is well known that an artificial denture after a time often does not fit the mouth of an elderly person as well as it did originally. It is also commonly held that the jaws atrophy as the years go by, and that such atrophy is pronounced in toothless persons. However, these matters have not been studied scientifically; and no relevant papers have been published. Hence a review of literature regarding this problem cannot be furnished.

*Fig. 1. Markedly degenerated mandible in an elderly person (Sicher and Tandler).*

As an illustration of the current view on the subject I refer to fig. 1. This is taken from Sicher-Tandler's well known handbook of anatomy and shows a very pronounced atrophy of the mandibes.

From time to time various anthropometrical systems have been proposed. Nowadays, however, Martin's is generally accepted. The following of his measurements have a bearing upon our subject: intercondylar distance, intergonal distance, height of mandibular symphysis, and angle of jaw.

Various methods of cranial roentgenography have been employed. The literature in question has been discussed by *Björk* (1947); therefore it is unnecessary for me to review it once again. It should be noted, however, that none of the works mentioned give any exact data for mandibular atrophy of age.

The problem will therefore be to attempt to determine, roentgenographically, the degree of age atrophies both in jaws with and in jaws without teeth. Owing to the difficulties of assembling an adequate number of test persons and the necessity of limiting the scope of the investigation, only certain age groups of subjects with no teeth and of subjects with complete, or nearly so, sets of teeth were studied. Intermediate types could not be taken into account, but the extremes are after all most important.

Special equipment is usually employed for roentgen examination of the skull, the rule being to use the sagittal but often also the frontal projection. The most useful apparatus seems to have been designed by *Broadbent*, *Margolis* and most recently by *Björk*. Common to them all is that the head is fixed with ear plugs, nose rest, or neck support. Further that the beam of rays can be projected in two directions at right angles to each other, as a rule through the auditory canal and in the medial plane perpendicular thereto. All three are also based on distance photography, the focus-film distance being about 155 cm (5 feet). Thus, the machines differ merely in technical details; the fundamental principles are basically the same.

## CHAPTER I

# Character of cases investigated

With respect to age and dental status the 451 men composing the *test series* were classified as follows:

| | | |
|---|---|---|
| Group | I, young men around 25 years of age with mandibular teeth | 100 |
| Group | II, young men around 25 years of age without mandibular teeth | 51 |
| Group | III, elderly men over 65 with mandibular teeth | 100 |
| Group | IV, » » » 65 without » » | 200 |

Age was the primary consideration in selecting the test subjects. In order to obtain the required groups it also was necessary to examine the dental condition. It was very difficult, naturally, to find elderly persons with teeth. Particularly the difficulties with the younger group have rendered the series less numerous than intended originally.

The age distribution appears in table 1. It will be seen that the mean age in group I (young persons with teeth) is sligrly less than 24 years, varying from 21 to 25. The mean age in group II is just over 24 and it also ranges between 21 and 25 years. The age distribution in group III (elderly persons with teeth) shows a mean of almost 72 years and varies from 65 to 82 years. One person, however, is as old as 86. Group IV (elderly toothless persons) has a mean age of 72 and varies from 65 to 85 years, one person being 88 years old (table 1).

*Table 1. Distribution of the Cases according to Age*

| Age years | No. of Young Persons | | Age years | No. of Old Persons | |
|---|---|---|---|---|---|
| | with teeth | without teeth | | with teeth | without teeth |
| a) Young persons | | | 72 | 6 | 5 |
| | | | 73 | 6 | 3 |
| 21 | 5 | 2 | 74 | 10 | 4 |
| 22 | 19 | 4 | 75 | 8 | 4 |
| 23 | 23 | 6 | 76 | 2 | 6 |
| 24 | 22 | 2 | 77 | 3 | 3 |
| 25 | 38 | 37 | 78 | 1 | 3 |
| Total | 100 | 51 | 79 | 3 | 3 |
| | | | 80 | 1 | 2 |
| Mean age | 23.7 | 24.3 | 81 | 1 | 3 |
| | | | 82 | 1 | 3 |
| b) Old persons | | | 83 | — | — |
| | | | 84 | — | 1 |
| 65 | 15 | 22 | 85 | — | 4 |
| 66 | 5 | 3 | 86 | 1 | — |
| 67 | 8 | 6 | 87 | — | — |
| 68 | — | 2 | 88 | — | 1 |
| 69 | 11 | 2 | | | |
| 70 | 9 | 11 | Total | 100 | 100 |
| 71 | 9 | 9 | Mean age | 71.6 | 72.1 |

In groups I and III the criterion for dental status was that each of the test persons should have a complete row of teeeth in at least half the lower jaw and in addition incisors. It proved extremely difficult, though, to encounter an adequate number of oldsters with a complete row of teeth remaining, so the criterion for dental status had to be modified somewhat. The finally accepted minimum requirements were one sound molar and three incisors.

## *Age Distribution*

The persons in group I (young men with teeth) were either students at the Institute of Dentistry, Stockholm, or private patients. Group II (toothless young men) was a few cases recruited from the

clientèle at the Institute of Dentistry, but the majority came in response to advertisements in the daily press. A promised remuneration seems to have been an incentive. Among the 51 persons in this group 39 were born outside Stockholm, whereas 12 of the rest themselves were born in or close to Stockholm to parents of rural extraction. The group of elderly men with teeth were mainly recruited from various homes and institutions for the aged in Stockholm; and I am indebted to the managements of these institutions for their kind assistance. Patients in this group also came from the Institute of Dentistry, from other dentists and my own practice, and occasionally in response to newspaper advertisements. Toothless elderly persons were assembled from institutions for old people and from the clientèle at the Institute of Dentistry.

With respect to the important question whether a series collected in the manner outlined above may be considered representative, it may be mentioned that no selection took place according to the condition of the jaws (except for the number of teeth). Hence there is no reason to consider the series unrepresentative, unless the fact that the subjects came from a metropolitan environment can have influenced the configuration and atrophy of the mandible.

It would, of course, be the best method to compare the persons at different years of age. This clearly is impossible. Therefore we had to compare persons of different ages and consequently the standard errors in this way become a little larger. Furthermore, an element of selection may be said to be involved when we compare persons who have lost their teeth. However, these elements of selection should go in different directions and thus be fairly obvious.

For the sake of completeness we shall give some data on the social status of the studied persons. To some extent the social status of a person can be regarded as an indicator of whether he has had dental care. The elderly persons — particularly those with teeth — from an occupational point of view represented very diversified categories, though their social status at the time of the investigation might be considered low. Quite a lot of them were inmates of institutions for the old. The rest were clients at the Royal College of Dentistry. Most of them probably had received no dental care to speak of. The young test persons without teeth came from different social levels and

various parts of the country. The large majority of the young persons with teeth were students who also were recruited from all parts of Sweden.

The following aspects may be laid on the question whether our test group can be considered representative of a cross-section through society. It might seem as though there were a pronounced social difference between, on the one hand, the young test persons with teeth, most of whom were students of university standard, and, on the other, the group of elderly persons, most of whom came from institutions of various kinds. It might be thought also that these elderly men had their childhood and adolescence at a time when the nutritional and hygienic standards were quite different to ours. However, it is impossible to judge the extent to which such factors may have influenced the representativeness of our test groups. It should be borne in mind, moreover, that Swedish students of our day by no means represent a single social segment with a decidedly higher standard of living than others.

CHAPTER II

# Methods

## 1. *Direct measurements*

As has been indicated earlier, the study was conducted along two lines: direct measurement on the patient and measurement on roentgenographs.

The measurements taken directly with a common goniometer or a vernier gauge were the following:

a. the intercondylar distance
b. the external intergonial distance
c. the medial distance from the lower edge of the chin to the top of the incisors
d. the medial distance from the lower edge of the chin to the edge of the gum, in toothless test persons.

a. according to *Martin* (65) the intercondylar distance is defined as the distance between the two lateral condyles; obviously the taking of this measurement is especially prone to be erroneous, the foremost reason being that the articular prominences are more or less difficult to palpate, depending on the construction of the joint.
b. The intergonial distance is the distance between the two gonia (*Martin* 66).
c. and d. The height of the chin was measured along the medial line with a vernier gauge. In people with teeth it may happen that the

central incisors are unequally long. In such cases the mean of the distance to the tops of the incisors was used. In toothless persons the height of the chin was taken to be the distance from the pogonion to the margin of the gum, as measured with a vernier gauge.

## 2. *Roentgen examination*

Corresponding measurements in roentgenographs of different persons are not comparable unless the test persons' heads are oriented in about the same way in relation to the X-ray beam and the film. In other words, the object is to achieve a rigid and reproducible relationship between X-ray beam and some identical anatomical details in the head and film plane.

Two pictures, a frontal and a prophile, are required of each person for studies of this type. For this purpose *Broadbent* uses two roentgen machines with beams at right angles, enabling the patient to retain the same position for both projections. If only one machine is available, the patient must instead be rotated 90 , as described by *Margolis*. The latter method was used in the present investigation.

Moreover, the direction of the X-ray beam must be reproducible in relation to the cranium, and so must the position of the film in relation to the beam, it being particularly important that the »central ray» always strikes the film at right angles. For prophile pictures the openings of the external auditory canals are the most common marks and they were the ones used in this investigation. We availed ourselves of a pair of movable rests on the cephalometer with end plugs about 20 mm long and - mm wide. The plugs were made of Plexiglass which is durable and hard, but does not inconvenience the patient, and offers little resistance to X-rays. The ear plugs having been inserted in the external auditory canal, the chair was lowered enough to let the plugs exert a light pressure against the cranial wall of the openings. The plugs were marked by pressing a lead pellet into the right and sliding a metal sleeve over the left. Directed through these ear plugs, the central beam will then depict the lead pellet as a round spot within the annular shadow of the metal cylinder.

The following principles of orientation were used for the frontal projections. With an antero-posterior beam, the path of the central ray was directed along the intersection of the Franfurter and median planes.

My main contribution to earlier constructions is a vibrating secondary aperture whereby contrast is improved and fixation of reference points simplified. Being compelled to build an apparatus

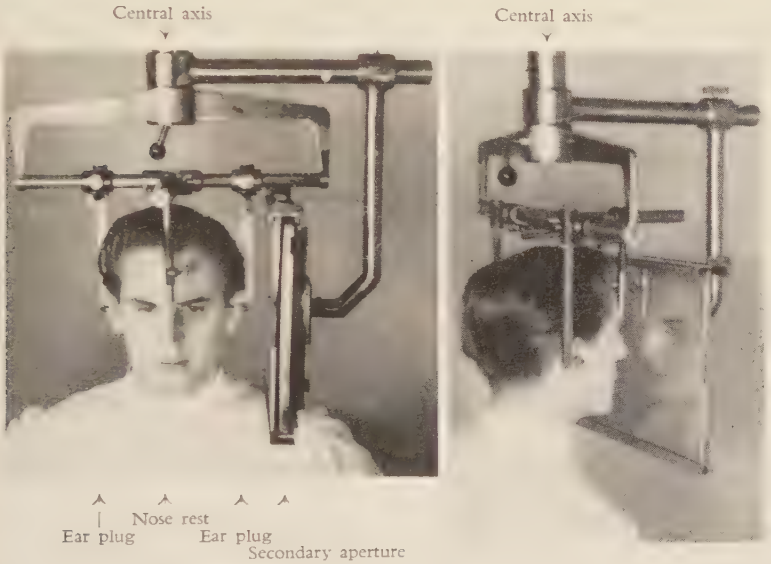



*Fig. 2. Cephalostat. Left: Profile view. Right: Frontal view.*

especially for this investigation, I naturally drew upon the experiences made earlier by *Broadbent* as well as by Swedish investigators, chiefly *Björk* who kindly showed me his apparatus and informed me of his experiences. For this I thank him sincerely.

In previously mentioned constructions the distance between film and focus is 155 cm (5 feet). I used the same measurement, but owing to the secondary aperture just mentioned, the distance between intercranial reference points and film differs. The secondary aperture takes up 6 cm, which made the distance from the film to the median plane 15 cm in my experiments while, for example, *Björk's* corresponding distance was 9 cm. My degree of

photographic enlargement hereby obviously became different to *Broadbent's* or *Björk's*. It can be shown theoretically that the longer distance between film and reference points demanded by my construction magnified my pictures 3.5 to 4 per cent more than the former authors'.

However, in order to check the degree of enlargement in practice, I used wire indicators with notches 2 mm apart. By measuring the distance between these notches on the roentgenographs and comparing it with the actual distance, one can therefore estimate quite precisely the enlargement ratio. Having an all-over length of 2 cm, one of these indicators was placed along the ridge of the nose, one vertically on the chin, and one on each side behind the angle of the jaw. Graduation of the indicators made it easy to distinguish the right from the left.

Exposure data: Frontals, 90 KvP, 110 Ma, $1^3/_4$ sec.
Sagittals, » , » , $1^1/_4$ » .

Exposure times varied $\pm {}^1/_4$ sec. accordingly as the skull was considered thick or thin.

*a. Photographic method*

With regard to the photographic method the following may be mentioned also.

Three photographs were taken of each test person: one lateral, with the person's left side facing the film, and two frontal pictures, one with the central ray passing through the Frankfurter plane and the other at a varying angle to the median plane. The reason for the latter picture was a wish for distinct outlines of the articular prominences, so that the intercondylar distance could be measured. This required different orientations of the test person depending on the cranial structure and, particularly with respect to the old persons, the ability to assume the most suitable attitude in relation to the film. It follows that the skull was oriented in the X-ray beam partly in the Frankfurter plane and partly according to the varying cranial structures.

The question then arises how these orientation differences in principle affect the projection of the mandible, i. e. how the altered position of the mandible in the beam altered the distances between

the points of reference in the roentgen image. Also another matter should be observed in this connection. With regard to orientation in the Frankfurter plane the jaws were, as will be described subsequently, standardized by letting the patients bite on a block, while they were asked to open their mouths as much as possible when the beam was directed differently. We must therefore especially in regard to one measurement try to find out to what extent the factor of a more or less open mouth changed mandibular orientation and affected the results.

At maximal separation of the jaws without strain, the ventral-caudal displacement of the condyle can be estimated to about 1 cm. Thus, this displacement is made up of one horizontal and one vertical component. Forward rotation of the head about the axis of the ear plugs depresses the head of the joint caudodorsally much farther when the mouth is open than when it is shut. This in part cancels the ventral horizontal displacement due to an open mouth. It is perhaps safe to assume that about 20 forward rotation of the head in relation to the Frankfurter plane would produce a dorsal displacement equivalent to the ventral displacement due to an open mouth, and that the distance from reference points to film therefore would be unchanged. In any case the difference should be of an order such that it would not be measurable at the adopted focal distance.

*b. Roentgenographic measurements*

Both distances between certain points and areas of certain surfaces were measured on the jaw roentgenographs.

**A. Persons with teeth.** Profile pictures

a. *Mandibular height* (fig. 3). The base line was a tangent to the lower margin of the mandible drawn through its two caudalmost points. (*Martin* points out that there may not always be two such points: the lower mandibular margin can be smoothly convex. My series included no such cases.) A perpendicular was then drawn from the medial cutting edge to the base line. The distances along the perpendicular were measured from base line to alveolar ridge and to cutting edge.

*Fig. 3. Mandibular height to cutting edge and to alveolar ridge.*

*Fig. 4. Lower ramal width.*

b. *Lower ramal width* (fig. 4). A line from incisal cutting edge to highest 2nd molar cusp was extended through the ascending ramus. Along this line the distance was then measured from anterior to posterior ramal edge.

c. *Upper ramal width* (fig. 5). Here the author used the maxilla to fix a measurement in the mandible. Such being the case the dif-

*Fig. 5. Upper ramal width.*

*Fig. 6. Length of mandibular base.*

ferent individuals in the test group must of necessity keep the mandible in the same position in relation to the maxilla. This was achieved by placing a wooden block of 7 cm thickness between the incisors. Sources of error can naturally not be avoided: the incisors may be unequally long, the teeth may be anomalous, or more or less worn down in different persons. Such sources of error are of course unavoidable. No previous investigator seems to have made use of this measurement, and I have therefore had no data to go by. I have localized the points of reference as follows.

The lateral projection of the cortical bone in the base of the nose shows a marked dorso-frontal light line. Usually it is not so visible in the immediate neighbourhood of spina or crista nasalis, but beside this region the contrast is usually very high. The line is not always straight and can be curviform. From the frontal end of this line, to the dorsal boundary and across the mandible I draw a straight line. The required measurement is the distance from the frontal to the dorsal margin of ramus ascendens along the line just drawn.

d. *Length of mandibular base* (fig. 6). The distance between the intersections of the aforementioned base line through the two caudalmost mandibular points and a line perpendicular thereto through the pogonion and a vertical line touching the two dorsalmost points on ramus ascendens.

*Fig. 7. Ramal height.*


*Fig. 8. Height, including resp. excluding coronal height, around the left 2nd molar.*

e. *Ramal height* (fig. 7). The distance from the point of intersection of the base line and the vertical line through the two dorsalmost ramal points and the intersection between the latter and a line at right angles thereto through the highest point on the capitulum.

f. *Height, including coronal height around the left 2nd molar of horizontal mandible* (fig. 8). The distance, measured along a line at right angles to the base line, passing through the highest distal coronal point, from the tip of the cusp and from the alveolar ridge to the lower mandibular margin.

g. *Mandibular width between outer and inner jaw angles* (fig. 9). The distance from the internal to the external mandibular margins measured along the continuation of the bisector of the angle between the aforementioned lines through the caudal and dorsal mandibular margins.

*Fig. 9. Mandibular width between outer and inner jaw angles.*

*Fig. 10. Angle between base line and tangent to dorsal margin of ramus ascendens.*

h. *Angle between base line and tangent to dorsal margin of ramus ascendens* (fig. 10).

i. *Total surface area of lateral projection of mandible* (fig. 11).

For technical reasons measurements of area as a rule provide less reliable results than measurements of length. We have therefore

obtained a mean of two measurements by measuring the area twice and halving the sum.

j. *Area of horizontal mandible* (fig. 12). The area in front of the aforementioned line through the external and internal angles of the jaw, in the same manner as the total surface was measured.

*Fig. 11. Total surface area of lateral projection of mandible.*

*Fig. 12. Area of horizontal mandible.*

**B. Persons with teeth.** Frontal pictures

a. *Height of chin* (fig. 13), measured along the midline from the medial incisal cutting edge to the lowermost point on chin

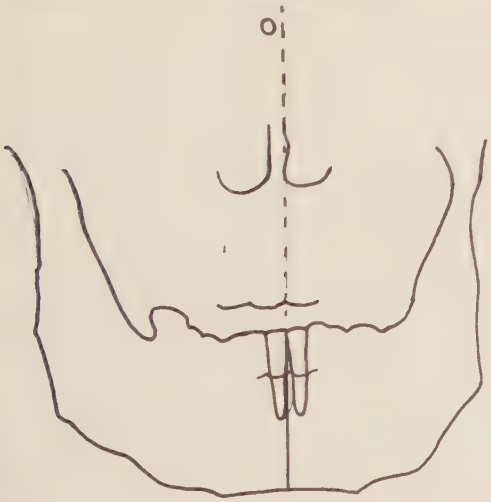


*Fig. 13. Height of chin, including resp. excluding coronal height*

(gnathion). The mean incisal length was used when the medial incisors were unequally long. Along the same elevation the distance was measured from the alveolar ridge to the basal margin of the mandible.

b. *Intergonial distance* (fig. 14), distance between most laterally of reference is not identical to the aforementioned dorsocaudal point in the profile pictures.

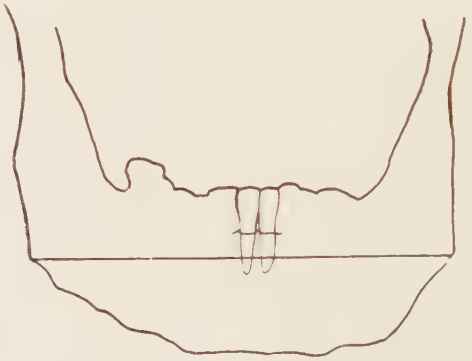


*Fig. 14. Intergonial distance.*

c. *Ramal width* (fig. 15). The distance between the medial and lateral contours of ramus ascendens, as measured along a line tangential to the lowest points on the piriform aperture.

Sometimes, however, it may be difficult to determine what roentgenographic detail represents the piriform aperture, for a frontal picture often displays several adjacent contrast lines. Then one must distinguish between the apertural line, the line representing the dorsal margin of roof of the mouth, and the curve of the base of the nose. Sometimes these lines are superimposed, whereas they fairly often lie some small distance apart. As a rule the apertural line should be easy to pick out, owing to the greater contrast. With the beam directions used for the present investigation it usually is also the caudalmost of the three lines. Sometimes it may be necessary to pay attention to the visualization of the spinal column as well.

Owing to the anatomic variation of the aperture on either side of the septum, the tangent may occasionally be inclined and cut the

rami at different levels. However, this disadvantage is cancelled out by measuring both rami, so that the too high level on one is compensated by the too low level on the other.

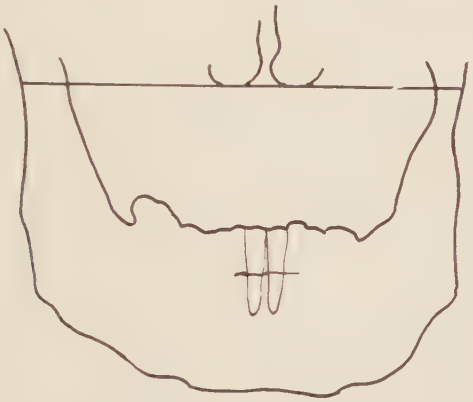


*Fig. 15. Width of left and right ramus ascendens.*

d. *Intercondylar distance* (fig. 16) is measured along the outer margins of the two condylia lateralis.

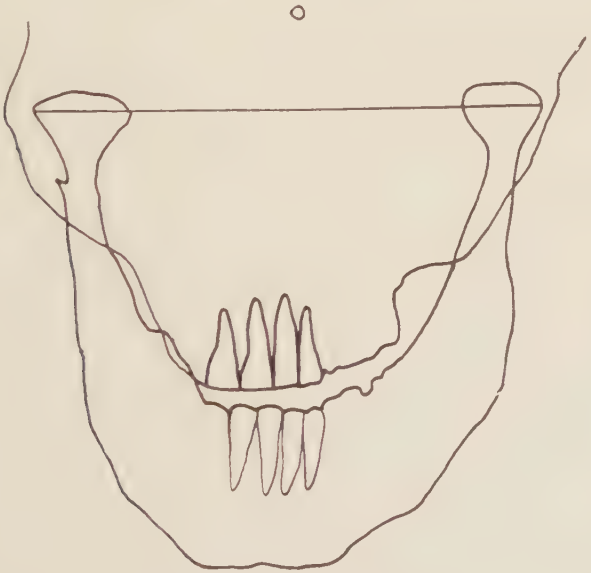


*Fig. 16. Intercondylar distance.*

**C. Toothless persons.** Profile pictures.

On the whole the same measurements were taken in this group as in the group with teeth (A).

As dental points of reference are lacking the following exceptions had to be made.

The measurements representing height of jaw and ramal width could not be taken. In respect of other measurements the points of reference were exchanged for others.

*Fig. 17. Jaw height along medial line.*

*Fig. 18. The height of the horizontal mandible around the 2nd molar.*

*Jaw height along medial line* (fig. 17). This quantity must be measured rather more schematically in persons without teeth. A perpendicular is dropped from the apex of the alveolar ridge, which often is distinctly marked, to the base line, and along it the height of the jaw is then measured.

*The height of the horizontal mandible and the 2nd molar* (fig. 18) must similarly be measured rather roughly. We measured it along a perpendicular to the base line, at a distance of 5 cm from the pogonion. The distance 5 cm was selected after trial measurements on 25 persons with teeth, it being found that the mean distance from distal cusp of the 2nd molar to the pogonion is 5 cm.

**D. Toothless persons.** Frontal pictures.

Here also the points of reference differ from those used when teeth are present. This applies particularly to *Jaw height* (fig. 19) which here is the medial distance between the upper and lower free mandibular margins, the midline being taken as the nasal septum.

With respect to the measuring technique, it should be noted that the points of reference were not marked on the negatives because of the necessity for making double determinations. The pictures were instead traced on translucent paper on which measuring was carried out directly.

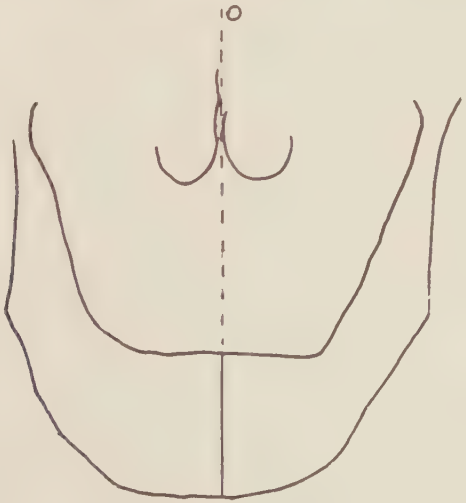


*Fig. 19. Jaw height.*

*Fig. 20. Profile roentgenogram of a person with teeth. Ear plugs are shown behind the condyles. Indicator wires on the nose and mental region. The jaw indicator is smaller and thicker then the right one.*

*Fig. 21. Frontal roentgenogram of a person with teeth.*

*Fig. 22. Frontal roentgenogram of a person with teeth. Measuring of the intercondylar distance.*

*Fig. 23. Profile picture of person without teeth. Indicator wires as before.*

*Fig. 24. Frontal picture of person without teeth.*

*Fig. 25. Frontal picture of person without teeth. Measuring of the intercondylar distance.*

### 3. *Sources of error*

An investigation involving the methods outlined above obviously embodies various sources of systematic and random errors.

Firstly, as regards the roentgenograph itself, any errors may be attributed partly to slightly varying localization of the jaw halves in lateral pictures and partly to inadequate precision in fixing the selected points of reference.

The selection of the right and left half of the jaw in the lateral picture may as a rule be based on the geometrical effect of the divergent X-ray beam and its orientation. If the central ray passes exactly through the external auditory canal and the skull is bilaterally symmetrical, the fact that the auditory canal lies dorsally of and approximately in level with the articular prominences will render the dorsal and caudal contours of the two jaw halves distinguishable, the dorsal and caudal contours of the jaw half nearest the film being depicted dorsally and cranially, respectively, in relation to the corresponding contours of the other jaw half. Nevertheless, the displacement will be so small that the anatomic variation between the two jaw halves might obscure the geometric effect.

For this reason the following steps were taken. Prior to photography indicator wires were placed on the skin bilaterally just below the auditory canal as close as possible to ramus ascendens. If in fact the indicator wires are equally long, they should in sagittal projection seem to be unequal in length so that the right and the left wire will be fully identifiable. It would be reasonable to suppose that in relation to each other in dorsofrontal projection they would be placed similarly to the corresponding mandibular margins.

Furthermore, I have reexamined all the roentgenographs to see what proportion of them are doubtful concerning the orientation in the picture of the mandibular halves. I obtained the following result.

The dorsal margin of the left ramus ascendens is depicted dorsally of or superimposed on the dorsal margin of the left ramus in 265 cases. The left margin is ventrally of the right in 93 cases; and the base line of the left mandibular half lies cranially of, or on the same level as, the corresponding right base line in 321 cases and the reverse in 19 cases.

The relationship between the left and right ramus ascendens was also compared with the ratio between the indicators applied on the right and left side behind ramus. It turned out that the disproportion between the two ramal branches agreed with the disproportion between the indicators in 307 cases and disagreed in 26 cases.

It follows from the above that the right and the left sides of the mandible as a rule can be distinguished owing to agreement between two of the three factors: displacement between the ramal margins, the base lines and the indicators.

In order to decide the sources of error three complete sets of measurements were taken, two by the author and one by an amanuensis. Herein lies primarily a source of error: unintentionally the measurements might have been made from different points. For example, it is often difficult when measuring directly on the patient to find the exact point to measure from, and the presence of soft tissues makes it hard to palpate precisely the finer bony prominences.

The roentgenographs were transferred to tracing paper over a specially adapted source of light, only the lines and points required for the measurements being marked out. I made two tracings myself and an amanuensis a third. Sometimes we were at odds regarding the choice of a point or line, particularly when other features of the facial skeleton were superimposed on the required item. An error of this type will naturally be greater the shorter is the distance to be measured.

To obtain a comprehensive estimate of the most influential errors, i.e. random errors, duplicate determinations were made. These were then used to evaluate the error of a single determination according to the formula:

$$\sigma = \sqrt{\frac{\Sigma d^2}{2n}}$$

where $d$ is the difference between duplicate determinations and $n$ the number of such differences. The results obtained are disclosed in table 2.

The author's two measurements were most divergent with regard to the height of the chin, the error of measurement in per cent of

*Table 2. Differences between the Author's Duplicate Measurements taken Directly on test Persons. Error of Measurement according to the Formula* $\sigma_i = \sqrt{\frac{\Sigma d^2}{2n}}$

| Distances in mm | No. of test persons | Mean of the differences in mm (a — b) $M \pm \varepsilon (M)$ | Error of measurement $\sigma_i$ | Error of measurement in % of the mean |
|---|---|---|---|---|
| Distance from incisal edge to gnathion ..... | 35 | $0.34 \pm 0.15$ | 0.66 | 1.47 |
| Intergonial distance ..... | 35 | $-0.04 \pm 0.17$ | 0.71 | 0.66 |
| Intercondylar distance..... | 35 | $-0.09 \pm 0.21$ | 0.87 | 0.66 |

the corresponding mean here being 1.47, whereas the intergonial and intercondylar distances have an error of measurement no greater than 0.66 per cent.

In measuring the but 20 mm long indicators a relatively large percentage error is to be expected, because of the lack of reliability inherent in the tracing procedure. Furthermore, the measurements could only be exact within 0.5 mm. (Cf. table 3.)

*Table 3. Mean Differences between the Author's Duplicate Measurements of Indicator Length on Profile Roentgenographs and the Error of Measurements in mm.*

| Indicators | No. of duplicate determinations | Difference in mm (a—b) $M \pm \varepsilon (M)$ | Error of measurement $\sigma_i$ | Error of measurement in % of the Mean |
|---|---|---|---|---|
| On left cheek .. | 34 | $-0.096 \pm 0.062$ | 0.259 | 1.24 |
| On right cheek . | 34 | $-0.007 \pm 0.050$ | 0.203 | 0.90 |
| On nose..... | 33 | $0.114 \pm 0.064$ | 0.270 | 1.23 |

It will be seen from table 3 that the discrepancy between the author's two sets of measurements was about 1 per cent of the mean and ranged between 0.90 and 1.24 per cent.

However, the really important thing is to determine the random error of measurement on a roentgenograph. We may get some idea of this by considering 35 duplicate measurements on profile roentgenographs. A statistical analysis provides the following results.

The author's error in making length measurements varied between 1 and 2.6 per cent of the mean, the greatest errors lying within the roentgenographically obscure ramal region (table 4). The error of measurement for the angle of the lower jaw was 0.5 per cent. None of the mean differences had a significant deviation from 0.

*Table 4. Mean differences between the Author's Duplicate Measurements on Profile Pictures, Errors of Measurement, Means for the Author's two Series (a and b), and Errors of Measurement in Per Cent of Corresponding Means*

| Measurements on profile roentgenographs in mm and degrees | No. of duplicate determination | Difference in mm (a—b) $M \pm \varepsilon(M)$ | Error of measurement $\sigma_i$ | Mean of a and b | Error of measurement in % of mean |
|---|---|---|---|---|---|
| Incisal edge—gnathion | 35 | $0.30 \pm 0.18$ | 0.78 | 53.6 | 1.46 |
| Highest 2nd molar cusp-mandibular rim | 35 | $-0.06 \pm 0.17$ | 0.69 | 35.1 | 1.95 |
| Ramal width in occlusal plane | 35 | $0.19 \pm 0.21$ | 0.88 | 34.1 | 2.59 |
| Ramal width in nasal plane | 35 | $0.01 \pm 0.19$ | 0.78 | 38.2 | 2.05 |
| Length of Corpus mandibulare | 35 | $0.30 \pm 0.22$ | 0.95 | 92.3 | 1.03 |
| Length of ramus | 35 | $-0.03 \pm 0.23$ | 0.95 | 66.8 | 1.42 |
| Mandibular angle (in degrees) | 35 | $-0.01 \pm 0.15$ | 0.63 | 129.2 | 0.49 |

There remains to be studied the error of measurement on frontal roentgenographs, but there is no reason to presume that it will deviate materially from that on profile pictures.

The measurements taken by the author were compared with those taken by someone else, since thereby it would be possible to ascertain if systematic errors were involved. Actually, however, such a comparison would not yield a true impression unless several persons' measurements were interrelated which, of course, could not be done

for practical reasons. The duplicate determinations here cited are given merely as random samples and by no means provide a complete picture. It should be noted, moreover, that since all those measurements upon which the analysis was based were taken by the author the systematic errors do not influence the results arrived at.

The results of a statistical analysis will be seen in table 5. It reveals that the systematic error between the two persons is negligible and not even significant, which provides some measure of security. The two persons might be said to have measured practically alike.

*Table 5. Mean Differences between the Author's Duplicate Measurement (a and b) Series on Frontal Roentgenographs and the Error of Measurement in Per Cent of the Mean, and Corresponding values for the Author's First series and the Amanuensis' Series (c)*

| Measurements on frontal roentgenographs in mm | No. of duplicate determinations | Difference in mm (a—b) $M \pm \varepsilon(M)$ | $\sigma_i$ in % of the mean | Difference in mm (a—c) $M \pm \varepsilon(M)$ | $\sigma_i$ in % of the mean |
|---|---|---|---|---|---|
| Incisal edge—gnathion | 35 | $-0.07 \pm 0.17$ | 1.66 | $0.10 \pm 0.18$ | 1.74 |
| Intergonial distance .. | 35 | $-0.19 \pm 0.19$ | 0.71 | $-0.21 \pm 0.19$ | 0.73 |
| Ramal width in nasal plane, left ..... | 35 | $-0.16 \pm 0.09$ | 3.18 | $-0.24 \pm 0.12$ | 4.26 |
| Ramal width in nasal plane, right ..... | 35 | $-0.11 \pm 0.07$ | 2.83 | $-0.21 \pm 0.08$ | 3.24 |
| Intercondylar distance (external) ..... | 35 | $-0.26 \pm 0.18$ | 0.58 | $0.43 \pm 0.25$ | 0.81 |

The smallest measurements, the ramal widths, showed the greatest systematic errors, or 2.83 and 3.18 per cent of the mean. For the largest measurements, the intergonial and intercondylar distances, the percentage error dropped to respectively 0.71 and 0.58.

The mean of the percentage errors for the author's duplicate measurements was 1.59 per cent, whereas the corresponding figure for the author's and the amanuensis' measurements was 1.96 per cent.

CHAPTER III

# The Importance of Teeth for the Jaws

Two main problems will be discussed, namely:

1. The importance of the teeth for the dimensions of the jaws. This object was achieved by comparing within the age groups persons with and persons without teeth.

2. Jaw changes resulting from normal aging in persons with comparable sets of teeth. This was studied by comparing young persons with old persons in separate groups with and without teeth.

## *1. Direct measurements in the same age groups compared in persons with or without teeth*

### Direct measurements on test persons

As appears from table 6, three direct facial measurements were taken. Of these the mandibular height along the medial line cannot be used directly for comparing groups with and without teeth, as in these two instances the mandibular height is measured between different points, in one case from the incisal edge of the teeth and in the other from the alveolar ridge. If the difference is due to the teeth only and the height of the bone is not affected by their absence or presence, the difference will naturally signify the height of the teeth above the bone. If so the mean dental height would be 16.6 mm. Obviously, however, it is not certain that the difference is due solely to the incisal height. The two remaining measurements, on the other hand, can be used for direct comparison.

*Table 6. Means of Measurements taken directly on Test Persons with and without Teeth, and Difference between the Means*

| External distances in mm | Old persons | | | | | | |
|---|---|---|---|---|---|---|---|
| | With teeth | | | Without teeth | | | Differences with -without |
| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $D \pm \varepsilon(D)$ |
| Height of Corpus along middle line. On persons with teeth measured from cutting edge of medeal incisor to lower margin of jaw, and on toothless persons from alveolar ridge to lower margin of jaw .... | 99 | 48.68 ± 0.37 | 3.68 | 96 | 31.45 ± 0.48 | 4.70 | + 16.63 ± 0.61 |
| Intergonial distance ..... | 99 | 112.28 ± 0.62 | 6.21 | 96 | 110.34 ± 0.59 | 5.74 | + 1.94 ± 0.86 |
| Intercondylar distance..... | 100 | 138.95 ± 0.59 | 5.86 | 96 | 138.10 ± 0.63 | 6.12 | + 0.85 ± 0.86 |
| | Young persons | | | | | | |
| Height of corpus along middle line. On persons with teeth measured from cutting edge of medeal incisor to lower margin of jaw, and on toothless persons from alveolar ridge to lower margin of jaw .... | 99 | 45.58 ± 0.26 | 2.61 | 50 | 34.08 ± 0.54 | 3.80 | + 11.50 ± 0.60 |
| Intergonial distance ..... | 99 | 106.82 ± 0.45 | 4.48 | 50 | 106.70 ± 0.70 | 4.97 | + 0.12 ± 0.83 |
| Intercondylar distance..... | 99 | 131.51 ± 0.57 | 5.63 | 50 | 131.20 ± 0.77 | 5.46 | + 0.31 ± 0.96 |

There is no reason, however, to expect that in the same age group these measurements should be different in persons with and in persons without teeth. Actually there was no difference. Any aberrations are surely due to random variation and are at any rate too small to be of importance compared to the mean error. It would seem, therefore, as though the presence or absence of teeth does not affect the breadth of the jaw, either between the angles of the jaw or between the external points of the condyles.

### 2. *Indicators and the degree of roentgenographic profile magnification*

Two means of comparison are available to us: the direct measurements and roentgenographic measurements. These two types of measurements should show fair agreement, even if there are obvious differences. The first type of measurement is taken directly on living subjects and includes soft tissues. The second may be regarded as a direct bone measurement, but it is distorted due to magnification. To determine the influence of this distortion a number of special steps were taken.

Thin wires were, as mentioned in chapter II, affixed to the skin of the test persons, partly below the ears as close as possible to the distal margin of ramus ascendens mandibulae, partly on the ridge of the nose. These indicators were 20 mm long, and by taking measurements on the roentgenographs it was possible to compute the degree of magnification in the wire plane.

The mean length of the wire parallel to the ramus and closest to the casette was 21.02 mm, and that of the contralateral wire — i.e. furthest from the casette — 22.81 mm (see table 7). This is equivalent to a mean magnification, for example in old persons with theeth, of 5.1 per cent in the plane of the indicator closest to the film and 14.7 per cent in the plane of the indicator furthest removed from it. These figures enabled us to correct the measurements as taken on the films and transform them into actual, i.e. undistorted, measurements. It must, of course, always be remembered that an X-ray representation is a shadow picture and that contours that seemingly lie in the same plane by no means always do so.

*Table 7. Mean Indicator Lengths on Profile Roentgenographs of Persons with and the real*

| | Old persons with teeth | | |
|---|---|---|---|
| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ |
| Indicator behind ramus mandibulae, on left side | 98 | 21.020 ± 0.049 | 0.484 |
| Same on right side | 96 | 22.813 ± 0.059 | 0.574 |
| Indicator on ridge of nose | 95 | 22.000 ± 0.037 | 0.363 |
| | Young persons with teeth | | |
| Indicator behind ramus mandibulae, on left side | 95 | 20.968 ± 0.052 | 0.507 |
| Same on right side | 96 | 22.589 ± 0.067 | 0.654 |
| Indicator on ridge on nose | 89 | 21.933 ± 0.055 | 0.515 |

The discrepancy between the roentgenographic and the actual length of the indicator may obviously vary, since despite meticulous care it is impossible exactly to reproduce the same photographic conditions in every exposure. But individual differences in skull structure, giving rise to different degrees of enlargement, are probably just as, if not more important. Neither of these sources of error are, however, very significant. As units smaller than 0.5 mm are impracticable, the greatest discrepancies must surely be due to unavoidable errors of measurement. However, having devoted a special study to the variation caused by errors of measurement, we consider it unnecessary here to discuss the problem in detail. Any measurements given in the following have been corrected. Errors of measurement with respect to individual indicators have not been corrected for, since, being included in the total variability of the measurement, they may be disregarded.

### *3. Roentgenographic measurements in the same age group compared in persons with and in persons without teeth*

Elsewhere we have seen that measurements were taken on both frontal and profile roentgenographs. First we shall compare the profile values and then the frontal ones.

*and Persons without Teeth. Differences are also given between the Means size in mm*

| Old persons without teeth | | | |
|---|---|---|---|
| $N$ | $M - \varepsilon(M)$ | $\sigma$ | Difference with—without |
| 92 | 21.027 ± 0.057 | 0.549 | — 0.007 ± 0.075 |
| 96 | 22.755 ± 0.095 | 0.927 | + 0.058 ± 0.112 |
| 94 | 22.090 ± 0.046 | 0.449 | — 0.090 ± 0.059 |
| Young persons without teeth | | | |
| 51 | 20.833 ± 0.087 | 0.625 | + 0.135 ± 0.101 |
| 51 | 22.412 ± 0.079 | 0.565 | + 0.177 ± 0.104 |
| 51 | 21.961 ± 0.066 | 0.473 | — 0.028 ± 0.086 |

*Measurements on profil Roentgenographs*

On the profile pictures two mandibular measurements were taken: 1. the length of the base line from its intersection with the posterior ramal tangent to the perpendicular through the pogonion, i.e. the length of the horizontal branch of the lower jaw, and 2. the height of ramus mandibulae along the posterior ramal tangent from the base line to a line at right angles to the tangent through the superior condylar margin, the measurement here being called the ramal height. The angle between the base line and the posterior ramal tangent — the angle of the jaw — was measured at the same time.

Theoretically this angle might vary in the different groups. In young toothless persons with adaptable bones the angle of the jaw might be expected to increase, since otherwise the horizontal mandible could not maintain contact with the maxilla. The change in the angle would at the same time make the lower jaw jut more forward (cf. figs. 26 and 27).

It may be assumed, on the other hand, that old persons did not possess the same degree of adaptability when they lost their teeth. Therefore their jaw angle will have changed little if at all.

It should be unnecessary to point out that the respective persons had lost their teeth not at the time of examination but earlier. The

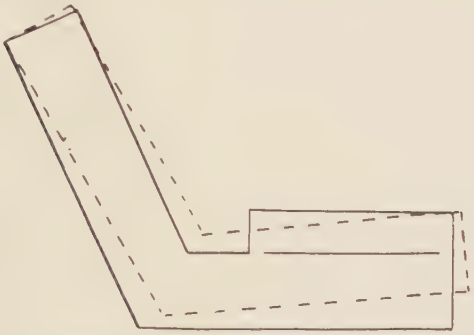


*Fig. 26. The solid line represents a jaw with teeth and the broken line a jaw without teeth. If the angle of the jaw remains constant and the teeth are lost, the corpus will bite only against the frontal part of maxilla.*

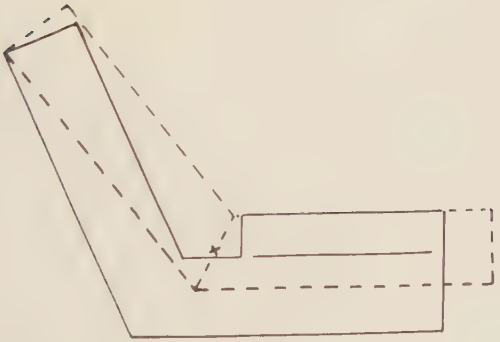


*Fig. 27. The solid line represents a jaw with teeth and the broken line a jrw without teeth. If the angle of the jaw changes a toothass mandible can retain f.ll contact with the maxilla.*

toothless period in elderly persons averaged 12.2 years. However, most of the test persons having lost their teeth successively owing to odontoptosis, the figure is rather uncertain. A tabulation of the subjects from this point of view reveals that about 90 per cent of the elderly toothless persons lost their last mandibular tooth at least 3 years before the examination, whereas the rest had lost single teeth every now and then up to the time of examination.

About 80 per cent of the young toothless test persons were equipped with a full lower jaw denture which they had worn for an average of 4.5 years. A very short time had as a rule elapsed between tooth removal and denture insertion. Most of them, however, probably did not use the prothesis at night, and in any case the bite pressure was reduced. Consequently adaptation might take place, particularly in the younger persons.

It would be interesting to know whether tooth losses reduce the ramal height and whether such a reduction is greater or smaller in old than in young persons. It is hard to form an opinion a priori on this matter. The adaptability of young persons is admittedly greater, but the disposition to atrophy in old persons could perhaps give rise to more marked changes.

It should be emphasized, furthermore, that in principle the change may be effected in two different ways: 1. The horizontal and vertical distances along the inner jaw angle are kept unchanged. On the lower boundary line both the arms must then be prolonged. 2. The lower boundary line is unchanged in length. If the angle is changed, both the arms must be shortened on the inner side. It seems probable that the change occurs midway between. (Figs. 26 and 27.)

We shall now examine how our expectations actually manifest themselves. Corrected for distortion owing to, the figures reveal (table 8).

In young persons there was a significant difference between the jaw angles of those with teeth and those without. The toothless mandible showed a mean jaw angle that was $7.37 \pm 1.21$ greater

*Table 8. Mean Measurements and Differences between the Means on Profile Roentgenographs. Jaw Angle in degrees. Base Length and Ramal Height for Young and Old in mm and Corrected for Geometric Distortion*

| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | Difference |
|---|---|---|---|---|---|---|---|
| Angle of lower jaw | Old persons with teeth | | | Old persons without teeth | | | |
| | 100 | 126.00 ± 0.70 | 7.05 | 100 | 126.67 ± 0.74 | 7.36 | −0.67 ± 1.02 |
| | Young persons with teeth | | | Young persons without teeth | | | |
| | 100 | 129.54 ± 0.73 | 7.28 | 51 | 136.91 ± 0.97 | 6.83 | −7.37 ± 1.21 |
| Ramal height | Old persons with teeth | | | Old persons without teeth | | | |
| | 100 | 67.15 ± 0.53 | 5.30 | 100 | 65.64 ± 0.57 | 5.66 | +1.51 ± 0.78 |
| | Young persons with teeth | | | Young persons without teeth | | | |
| | 100 | 63.71 ± 0.53 | 5.29 | 51 | 64.00 ± 0.70 | 4.99 | −0.29 ± 0.88 |
| Base length | Old persons with teeth | | | Old persons without teeth | | | |
| | 100 | 79.35 ± 0.52 | 5.24 | 100 | 78.36 ± 0.49 | 4.93 | 0.99 ± 0.71 |
| | Young persons with teeth | | | Young persons without teeth | | | |
| | 100 | 81.21 ± 0.46 | 4.60 | 51 | 77.86 ± 0.82 | 5.81 | 3.35 ± 0.94 |

than in the other group. In old persons, on the other hand, the absence of teeth did not seem to cause a corresponding deformation. To be sure, the angle was not significantly larger by 0.5 , and such a small difference does not even provide an indication of changes in the magnitude of the jaw angle. Consequently the facts seem to fit the expectation: the young mandible apparently adapts itself while the old does not.

In test persons with teeth compared with those without teeth the ramal height was 1.51 ± 0.78 mm longer in the old age group and 0.29 ± 0.88 mm shorter in the young age group than in toothless test persons. These differences are, however, not significant and may therefore be due to random variation.

Young toothless persons, on the other hand, showed a significantly shorter base length, the difference being 3.35 ± 0.94. Elderly persons revealed no significant difference. The small difference to be found in table 8 must therefore be a random one.

This indicates that at least the base line becomes somewhat shorter in young persons. Possibly this shorter base line in young persons is in some way secondary to the difference in the jaw angle.

We now pass on to compare the ramal width and the height of corpus mandibulae in these groups.

It is unlikely, as previously pointed out, that loss of the teeth should appreciably influence the various ramal measurements. Nevertheless, the toothless groups exhibited a ramus that was narrower in level with a plane through the floor of the nasal cavity (table 9). The differences are significant and amounted to $1.91 \pm 0.62$ mm in the old group and $5.26 \pm 0.57$ mm in the young group. The ramal width cannot very well change just because the teeth are lost.

*Table 9. Ramal Width in Level with the Floor of the Nose and at the Jaw Angle, and Height of Corpus at 2nd Molar and along Middle Line, on Roentgenographs on Persons with and Persons without Teeth, Means and Differences of the Means in mm*

| | | With teeth | | | Without teeth | | | Difference |
|---|---|---|---|---|---|---|---|---|
| | | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Ramal width in level with floor of nose | Old persons | 100 | $39.21 \pm 0.40$ | 4.00 | 100 | $37.30 \pm 0.47$ | 4.77 | $+1.91 \pm 0.62$ |
| | Young persons | 100 | $36.60 \pm 0.37$ | 3.74 | 51 | $31.34 \pm 0.43$ | 3.10 | $+5.26 \pm 0.57$ |
| Width at angle | Old persons | 100 | $32.47 \pm 0.36$ | 3.62 | 100 | $30.98 \pm 0.40$ | 4.00 | $+1.49 \pm 0.54$ |
| | Young persons | 100 | $30.77 \pm 0.34$ | 3.41 | 51 | $26.91 \pm 0.42$ | 3.06 | $+3.86 \pm 0.54$ |
| Height of corpus at seckond molar | Old persons | 100 | $24.87 \pm 0.36$ | 3.64 | 100 | $19.30 \pm 0.36$ | 3.63 | $+5.57 \pm 0.51$ |
| | Young persons | 100 | $22.98 \pm 0.26$ | 2.60 | 51 | $17.67 \pm 0.45$ | 3.10 | $+5.31 \pm 0.52$ |
| Height of corpus along middle line | Old persons | 100 | $33.97 \pm 0.32$ | 3.25 | 100 | $25.65 \pm 0.58$ | 5.24 | $+8.32 \pm 0.62$ |
| | Young persons | 94 | $33.61 \pm 0.29$ | 2.77 | 51 | $29.54 \pm 0.47$ | 3.36 | $+4.07 \pm 0.55$ |

A more probable explanation, however, seems to be that the measurements were taken in different planes in the groups without teeth compared with the groups with teeth. This question will be discussed in the following.

When the lower jaw grows straighter the spatial relationship between maxilla and mandible may change. Then the distal extension of the tangent to the floor of the nose will not hit the ramus where it would if teeth were present. The width of the ramus will consequently be measured at another place, but the difference in breadth is negligible. If the anterior and posterior ramal margins are parallel, the distance between them should be longer when the teeth are absent, since then the ramus is measured at a more obtuse angle than when the teeth are present. The anterior border of the ramus, however, is often concave in that very region. In such cases, owing to the altered projection, the distance may instead be shortened somewhat, when measured in the toothless, straightened lower jaw.

The most important reason why persons with and persons without teeth show discrepancies is probably that the ramus is measured at different places and in different directions. The starting point, which may be considered fixed, is the bottom of the nasal cavity. The measurements will therefore vary according to the position of the mandible when it is roentgenographed. In order to demonstrate this in extreme cases we photographed persons, partly with

*Table 10. The Ramal Widths with Jaws at Rest and with Jaws biting*

| Jaws at rest | Jaws biting | Difference |
|---|---|---|
| 40.5 | 36.5 | 4.0 |
| 36.0 | 35.5 | 0.5 |
| 40.0 | 38.5 | 1.5 |
| 36.0 | 33.5 | 2.5 |
| 42.5 | 41.0 | 1.5 |
| 38.0 | 39.0 | — 1.0 |
| 37.0 | 35.5 | 1.5 |
| 39.0 | 37.0 | 2.0 |
| 43.0 | 41.0 | 2.0 |
| 42.5 | 41.0 | 1.5 |

the mouth wide open and partly after telling them to bite or keep their mouth shut. The average difference (see table 10) turned out to be 1.6 ± 0.4, the distance being shorter when the mouth was shut. Here it should be noted that biting does not mean that the jaws are in contact. Resistance, for instance at the coronoid process, may prevent it; but that problem seems to lie outside the scope of this investigation and we have not tried to analyze it more closely. The main thing was to show that actually the ramal width differs, and that this difference might be due to variations of measurements.

At the junction of ramus and body the width of the mandible was measured along the bisector of the angle of the jaw. Also this measurement seems to be smaller in both groups of toothless persons. The difference was 1.49 ± 0.54 mm for elderly persons and 3.86 ± 0.54 mm for young persons. Only the latter difference is significant. The lower mandibular width in this region could be a result of the jaw angle changes.

The height of the corpus from the alveolar rim to the lower border of the mandible near the second molar in persons with teeth, and 5 cm behind the pogonion in persons without teeth, becomes smaller when the teeth have dropped out in both old and young persons, the statistically significant differences being 5.57 ± 0.51 mm and 5.31 ± 0.52 mm respectively.

The height of the corpus measured from the alveolar ridge to the gnathion decreases when the teeth are lost in old persons by 4.30 ± 0.67 mm and in young persons by 4.07 ± 0.59, both differences being statistically significant.

*Table 11. Means, Standard Deviations and Differences for the Total Side Surface of the Mandible in sq. cm*

| $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | Difference |
|---|---|---|---|---|---|---|
| | Old persons with teeth | | | Old persons without teeth | | |
| 100 | 37.50 ± 0.51 | 5.18 | 100 | 33.20 ± 0.42 | 4.23 | 4.30 ± 0.67 |
| | Young persons with teeth | | | Young persons without teeth | | |
| 97 | 34.00 ± 0.33 | 3.29 | 51 | 31.20 ± 0.48 | 3.45 | 3.70 ± 0.59 |

The influence, if any, on surface area was also studied. The total area of the lateral aspect of the mandible was selected for this purpose. (Table 11.)

The table reveals that there was a significant difference for the total area. In the groups with teeth it was 4.30 ± 0.67 $cm^2$ in elderly and 3.70 ± 0.59 $cm^2$ in young persons larger than in the corresponding toothless groups.

The dentigerous portion of the mandible, body and alveolar ridge, deserve the closest attention from the point of view of surface variation. This area was consequently measured separately (table 12).

*Table 12. Horizontal Mandibular Surface (from Pogonion to Jaw Angle) in sq. cm*

| $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | Difference |
|---|---|---|---|---|---|---|
| | Old persons with teeth | | | Old persons without teeth | | |
| 100 | 20.76 ± 0.26 | 2.62 | 100 | 17.27 ± 0.29 | 2.90 | 3.49 ± 0.39 |
| | Young persons with teeth | | | Young persons without teeth | | |
| 97 | 20.22 ± 0.21 | 2.07 | 51 | 16.76 ± 0.33 | 2.39 | 3.46 ± 0.39 |

For the horizontal section of old mandibles it was found that there was a significant mean difference of 3.49 ± 0.39 $cm^2$ in favour of those with teeth. Similar conditions were observed in young persons. Mandibular horizontal parts with teeth were larger in area, the significant mean difference being 3.46 ± 0.39 $cm^2$, i.e. young corpora mandibulae with loss of teeth showed practically the same surface diminution as the same part in old persons.

In the foregoing we have computed the difference and its standard deviation, as demonstrated roentgenographically, both for the total surface of the lateral mandibular aspect and for the surface of its horizontal portion. Both these areas being smaller for toothless jaws, it would be interesting to learn if the vertical part of the mandible is similarly affected. Experience seems to tell us that a diminution can be assumed primarily to affect the part of the mandible where the alveolar ridge has been absorbed owing to tooth

losses. Nevertheless, the possibility cannot be entirely excluded that the loss of teeth and consequent changes might have caused the ascending branch to undergo alteration in the size of the area.

The figures already given should provide some information in this respect, and we have therefore made up the subjoined tables. (Tables 13 and 14.)

*Table 13. Surface of Ramus Ascendens in sq. cm*
*(Figures obtained from Tables 11 and 12)*

| | Old persons with teeth | Old persons without teeth | Young persons with teeth | Young persons without teeth |
|---|---|---|---|---|
| Total lower jaw .. | 37.50 | 33.20 | 34.99 | 31.29 |
| Corpus ..... | 20.76 | 17.27 | 20.22 | 16.76 |
| Differences ramal surface | 16.74 | 15.93 | 14.77 | 14.53 |

*Table 14. Reduction of Ramal Surface after Loss of Teeth*

| | Old persons | Young persons |
|---|---|---|
| With teeth ..... | 16.74 | 14.74 |
| Without teeth..... | 15.93 | 14.53 |
| Difference | 0.81 | 0.24 |

It will be seen that the mean diminution of ramal surface in old toothless persons was 0.81 $cm^2$, whereas young persons without teeth showed a much smaller decrease, viz. 0.24 $cm^2$.

The assumption that the horizontal part of the mandible suffers most of the surface loss is hereby corroborated. It is a fact, though, that our demonstrated change in surface to some extent is at odds with one of our previous results. For we found no significant decrease in mandibular height; it lay wholly within the limits of normal variation. The fact that the horizontal surface of the man-

dible becomes smaller must be a result of the loss of teeth, and the reduction should in term shorten the ramus somewhat, but not enough for demonstration by the adopted method. However, the very exact surface measurements disclosed the shrinkage.

At an older age we expect some kind of atrophy, especially if the teeth are lost. On the other hand we also expect some kind of bone-addition. Both these processes may cancel each other to a certain extent and therefore the difference in area may be very small.

Some of the measurements taken on the frontal pictures are particularly interesting by virtue of their comparableness with the direct measurements. The distances referred to are the distance between the external angles of the jaw and the distance between the peripheral condylar points on either side.

The mean roentgenographic distance between the angles of the jaw in elderly men with teeth was 106 mm. The corresponding measurement in elderly persons without teeth was 103 mm. The difference, which is not significant, is only $22.25 \pm 0.85$ mm (table 15). The corresponding distances for young men were both about 101 mm, the toothless group showing an insignificant excess of $0.03 \pm 0.95$ mm. Compared with measurements taken directly on the test persons, it was found that the above roentgen picture distances were about 6 mm shorter in old and about 5 mm shorter in young persons.

Not being significant, the differences between the two types of dental status may be due to random variation. In dealing with direct measurements, however, it must be remembered that they include not only the bone but soft tissues as well. The found excess over roentgenographic measurements, about 0.5 cm, must be due to the presence of soft tissues.

The roentgenographically visualized distance between the peripheral condylar points may be similarly related to the intercondylar distance as taken directly from test persons. Irrespective of dental status the roentgenographically revealed intercondylar distance was practically constant, viz. between 121 and 122 mm with a not significant difference of $0.04 \pm 0.83$ for old men with teeth and between 119 and 120 mm with, similarly, a not significant difference of $0.70 \pm 0.91$ for young men with teeth. The direct measure-

*Table 15. Means and Errors of Measurement for Measurements in mm on Frontal Roentgenographs, Corrected for the Distortion*

| | | With teeth | | | Without teeth | | | Difference |
|---|---|---|---|---|---|---|---|---|
| | | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Distance from incisal edge to gnathion along middle line | Old persons | 100 | 41.38 ± 0.32 | 3.20 | 99 | 24.63 ± 0.47 | 4.74 | + 16.75 ± 0.57 |
| Distance from alveolar ridge to gnathion | Young persons | 100 | 40.17 ± 0.28 | 2.71 | 51 | 29.80 ± 0.63 | 4.49 | + 10.37 ± 0.69 |
| Intergonial distance | Old persons | 100 | 106.15 ± 0.63 | 6.41 | 100 | 103.93 ± 0.55 | 5.517 | + 22.25 ± 0.85 |
| | Young persons | 99 | 101.33 ± 0.52 | 5.17 | 51 | 101.36 ± 0.80 | 5.68 | + 0.03 ± 0.95 |
| Ramus sinister | Old persons | 100 | 11.82 ± 0.22 | 2.25 | 100 | 12.04 ± 0.22 | 2.22 | 0.82 ± 0.31 |
| | Young persons | 100 | 11.00 ± 0.20 | 1.95 | 51 | 12.10 ± 0.27 | 1.10 | 1.10 ± 0.34 |
| Ramus dexter | Old persons | 100 | 10.26 ± 0.24 | 2.44 | 100 | 17.71 ± 0.21 | 2.10 | — 1.45 ± 0.31 |
| | Young persons | 100 | 10.37 ± 0.17 | 1.72 | 51 | 11.44 ± 0.26 | 1.89 | - 1.07 ± 0.31 |
| Intercondylar distance | Old persons | 100 | 121.98 ± 0.60 | 6.03 | 100 | 121.94 ± 0.58 | 5.79 | + 0.04 ± 0.83 |
| | Young persons | 99 | 119.97 ± 0.55 | 5.48 | 51 | 119.27 ± 0.73 | 5.71 | + 0.70 ± 0.91 |

ments showed equal agreement. The respective values lay around 138 mm (diff. $0.85 \pm 0.86$) and 131 mm (diff. $0.31 \pm 0.96$). No conclusions can be drawn from any of these differences. The excess of direct over roentgen measurements was almost 17 mm in the high age group and about 12 mm in the low age group. These discrepancies may probably be attributed to the double layer of soft tissues, one covering the bone on each side of the face, which is included in the measurements.

In frontal projection the width of the ramus in level with the floor of the nose shows a bilateral diminution in persons without teeth. In elderly persons the difference is $0.82 \pm 0.31$ cm on the left side and $1.45 \pm 0.31$ cm on the right side, the former being probable and the latter significant. Both being significant, the corresponding differences in young persons are $1.19 \pm 0.34$ and $1.07 \pm 0.31$. If these differences are considered in the light of what has been said elsewhere regarding apparent changes of the ramus when teeth are lost, they turn out to support the theory that the ramus rotates[1] somewhat outwards when the teeth drop out, the shorter ramal width in this projection indicating that processus muscularis (which normally is visible medially of the coronoid process) by rotating will cover a gradually larger part of that process.

### *In the preceding section we found the following*

The results obtained can be summarized by means of fig. 27, 28, 29 and 30. They are so made that the picture of a young person is superimposed on that of an old person with an about equivalent set of teeth. In the composite profile picture the base lines and the angles coincide. In the composite frontal picture the median plane and the gnathion coincide. We find the following.

The sagittal roentgenographs (figs. 27 and 28) show, by comparing persons with and without teeth, that the angle of the jaw is smaller in young persons with teeth than in young persons without teeth (diff.: $7.37 \pm 1.21$ ). The angle, or the other hand, apparently does not change in old persons after a total loss of teeth.

1) *Rotation* here means what seems to be rotation in the roentgenograph, irrespective how the process is brought about.

*Comparison between profil roentgenograms of old persons with and without teeth. Base line and angulus are common*

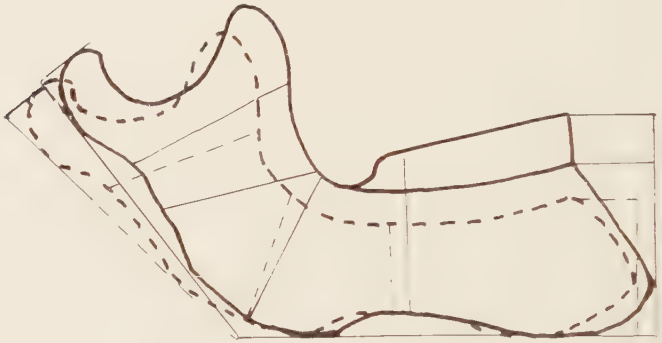


*Fig. 27. Young person with teeth* ————————
*Young person without teeth*— — — —

*Fig. 28. Old person with teeth* ————————
*Old person without teeth*— — — —

Compared to young persons with teeth, the base length in young persons without theeth shows a significant decrease. However, though it is not proved, this decrease might be secondary to the change of the jaw angle. The total surface area of the mandible in profile views shows a slight diminution after loss of teeth in both old and young men. For the most part this change seems to involve the ramal region. The author discusses the possibility that alterations

*Comparison between frontal roentgenograms of old persons with and without teeth. Medial line and gnathion are common.*

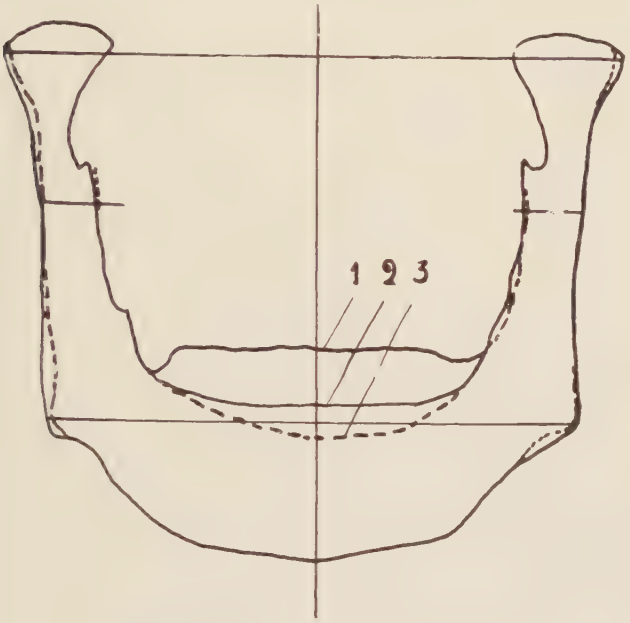



*Fig. 29. Old person with teeth* ————————
*Old person without teeth* — — — —
*1. Incisal cutting edge*
*2. Alveolar ridge*
*3. Mandibular margin*

of the measuring reference points gives rise to an illusory reduction of the ramal width and surface. It seems most unlikely that the reduction is real. Besides, the distance between the external angles of the jaw and the intercondylar distance show no significant changes following loss of teeth.

The hight of the profile of the mandible including teeth is, of course, greater than when teeth are absent. In elderly persons the difference between these levels along the medial line is $8.32 \pm 0.62$ mm and at the 2nd molar $5.31 \pm 0.51$ mm. This difference between persons who have lost their teeth and persons who still have them is less pronounced in young individuals, viz. along the medial line

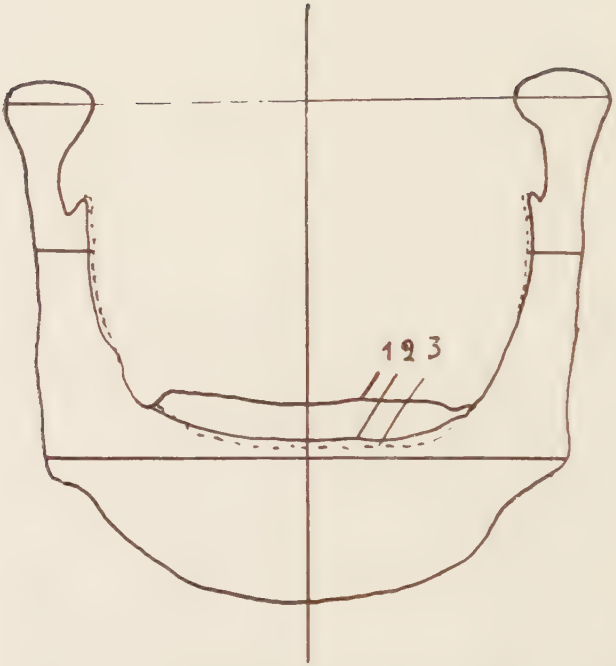



*Fig. 30. Young person with teeth* ————
*Young person without teeth* — — — —
*1. Incisal cutting edge*
*2. Alveolar ridge*
*3. Mandibular margin*

4.07 ± 0.55 and at the 2nd molar 5.31 ± 0.52 mm. The unequal differences in height between young and old persons probably depends on a pushing up of the teeth, the incisors especially, from their alveolar sockets, which process in part has counteracted increased abrasion down the years. The increase must be attributed to the expression of the tooth from the alveolar ridge. The increasing abrasion as the years go by is not great enough to cancel this displacement.

CHAPTER IV

# Changes caused by Age in Jaws of Men with and without Teeth

After an attempt to evaluate the effect of loss of teeth on mandibular size we now come to the main problem: to estimate the extent to which age influences the size of the jaw, irrespective of changes resulting when the teeth are lost. As mentioned before we had to remain content with comparing youths and persons 65 years old. This low age limit was chosen for practical reasons. Consequently we cannot make any statements concerning the changes taking place in very old persons.

The problem of growth is dealt with in a large number of papers by different authors. The question is whether the growing process continues after age 20—25. It does not seem to have been subjected to much empirical study. By means of mathematical formulas, whose validity has been demonstrated for young persons, some authors have attempted to calculate the growth after age 20. *Robertson* (1928), for example, using formulas for monomolecular chemical reactions, has suspected that the growth rate depends on a catalytic factor. In other words, at any given moment the speed of the reaction is proportional to the ratio between participating and formed reactant volumes. This hypothesis was criticized by *Backman* (1931), who pointed out that it leads to a mixture of symmetric and asymmetric functions. Backman expressed the opinion that, despite their inherent

weaknesses, *Robertson's* formulas adequately portray most of what happens during growth.

*Backman* has also tried to solve the growth problem himself. He defined growth as an increase of the living material due, among other things, to multiplication and constructive processes on the one hand and to differentiation and destruction on the other (1931).

Some of the outstanding points in our knowledge, he says, of human statural growth are: growth is irreversible; the rate of growth is initially high, and having reached a climax it slowly decelerates.

We recognize two main types of growth:

a. Asymptotic growth which continues throughout life and is stopped by death.

b. Terminated growth which takes place only during a definite period of life.

It is still an open question which parts of the anatomy are involved in the growth taking place after age 25.

With reference particularly to the stature of males, *Backman* (1938) stated that although men continue to grow throughout life the increase in stature after age 40—50 is as small as 0.01 cm per annum. This should imply that after this age a Swedish man grows practically not at all. However, his control series after 20 years age was very small, and his empirical figures do not quite fit his theoretical figures. For the present one must anyway accept the fact that after age 20 the stature increases very little and that available knowledge permits no definite statements.

No exact conclusions with respect to growth can be drawn from the direct measurements on men over age 24. The figures must perhaps be corrected by being multiplied with what is called Hultcrantz' figure. *Hultcrantz* (1927) has found that during the period 1850—1926 the mean statural increase of Swedish conscripts (mean of annual means in 1911) was 0.09 cm per annum. *Weissenberg's* investigations, based on inadequate series, seem to show that Hultcrantz' figure is valid for men up to age 60.

According to *Backman*, moreover, the growth rate is the sum of a constant basic rate, an acceleration and a retardation. He has

embodied his findings in formulas which he has tested and found to be fairly exact for statural growth. His test series included age groups from birth to age 70. Those in the range 21—70 years have a bearing on our problem. Although *Weissenberg's* empiric series was small we find in group after group that the theoretical increases in stature agree reasonably well with the actual measurements after correction with *Hultcrantz'* figure.

At this point it should be noted that the mathematical formulas are not valid for separate cases, they apply to means. If this were not so the growth rate would be fixed once and for all by the stature at birth or even before that. Such is not the case, for it is known that the growth rate can be accelerated or retarded as the case may be by various environmental factors. Consequently the formulas cannot be applied to separate cases and, if anything, it is astonishing that they produce such comparatively good results with means. Whether the rules for over-all statural increase apply to all parts of the body, e.g. the jaws, has not been established, but the possible validity of Hultcrantz' number for the mandibular region must be taken into consideration. If so the last 40 years will have broght about a longitudinal increment of approximately 2 per cent. The highest jaw measurements in our series are about 140 mm. Hence, in elderly persons these should be increased to 142.8 mm in order to be comparable with the same measurement in 25 year olds.

Provided that they obey the laws of growth, the cranial bones — particularly the mandible — should exhibit slight but definite increases in the higher age group. This tendency should, similarly, be somewhat retarded by senile reduction, because the latter phenomenon ought to have commenced in the younger and be marked in the older persons in the group. Furthermore, the young persons' measurements ought to be longer by virtue of the temporal growth increment, and only after correction with Hultcrantz' number will the figures for young persons be fully comparable with those for old subjects. As the correction should be very small and as furthermore, we have no exact knowledge of the rate of growth in what is called fullgrown people, no correction has been made in this material, whereby a slight error might arise.

## 1. *The Relation between Direct Measurements on Persons with and without Teeth in Different Age Groups*

The directly measured height along the medial line from gnathion to gingival margin in the groups without teeth and to incisal cutting edge in the groups with teeth can be compared.

Table 16 reveals that the mandibular height along the medial line in the toothless group was greater in the young than in the elderly persons. The difference, $2.63 \pm 0.72$, is significant and must be a measure of the age atrophy of the bones and soft tissues taking place in subjects without teeth. On the other hand, the height in elderly persons with teeth was increased and showed a significant difference of $2.50 \pm 0.45$. That in the latter case the difference was positive in behalf of the elderly persons may have been due to the longer time available for the teeth to emerge out of the alveoles. We have therefore supplemented the investigation by measuring also the roentgenographic shadow of the jawbone, the results being given later on.

The directly measured distances between the angles of the jaw and between the condyles showed better agreement. Both these distances were longer in the higher age group irrespective of dental status. The differences are significant and will therefore be discussed later in connection with the roentgenographic measurements. It seems, thus, as though we have to do with a matter of growth as the age increases. It should be noted, however, that the soft tissues are included in the measurement, and the elderly men may have more fat in theirs.

## 2. *Comparison of Roentgenographic Measurements on Persons with and without Teeth in Different Age Groups*

Before young and old persons can be compared their respective values must, as before, obviously be corrected for any photographic enlargement that may have taken place. This was achieved by using the previously described wire indicators. The figures are given in table 7.

It is probable that the cranial bones — particularly the mandible — would have been slightly larger in persons from the higher age group. Senile reduction, however, would have counteracted this

*Table 16. Means of Direct Measurements on Young and Old Persons with and without Teeth, and Differences between the Means for Young and Old*

| | Young persons | | | Old persons | | | Difference |
|---|---|---|---|---|---|---|---|
| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Jaw height from incisal cutting edge to gnathion, along medial line | | | With teeth | | | | |
| | 99 | 45.58 ± 0.29 | 2.91 | 99 | 48.08 ± 0.37 | 3.68 | − 2.50 ± 0.45 |
| Jaw height from alveolar ridge to gnathion, along medial line .... | | | Without teeth | | | | |
| | 50 | 34.08 ± 0.54 | 3.80 | 96 | 31.45 ± 0.48 | 4.70 | + 2.63 ± 0.72 |
| Intergonial distance ..... | | | With teeth | | | | |
| | 99 | 106.82 ± 0.45 | 4.48 | 99 | 112.28 ± 0.62 | 6.21 | − 5.46 ± 0.77 |
| | | | Without teeth | | | | |
| | 50 | 106.70 ± 0.70 | 4.47 | 96 | 110.34 ± 0.59 | 5.74 | − 3.68 ± 0.92 |
| Intercondylar distance (external) | | | With teeth | | | | |
| | 99 | 131.51 ± 0.57 | 5.63 | 100 | 138.95 ± 0.59 | 5.86 | − 7.44 ± 0.82 |
| | | | Without teeth | | | | |
| | 50 | 131.20 ± 0.77 | 5.46 | 96 | 138.10 ± 0.63 | 6.12 | − 6.90 ± 0.99 |

tendency, and its action had probably commenced in the younger and was pronounced in the older members of the group. The problem is which is dominant.

### *Measurements on profile Roentgenographs*

We shall as before first compare measurements from the profile pictures and then pass on to the frontal pictures. Mandibular development in adulthood may be expected to continue as in childhood, with the angle of the jaw year by year decreasing in size. During childhood, when bodily growth is dominant, one must regard the diminution of this angle as being due chiefly to a rapid growing process in that region. The problem we have to consider is whether such growth continues during adulthood (table 17).

As the years go by the jaw length after the ramal tangent grows longer. Our groups with teeth showed a significant difference of $3.44 \pm 0.75$ mm. A similar tendency seemed to prevail in the toothless groups, the more insignificant difference between them being $1.64 \pm 0.90$ mm.

*Table 17. Means of Roentgenographic Measurements in Sagittal Projection on Young and Old Persons with and without Teeth, and Differences between the Means for Young and Old. Reduced Measurements*

| | Young persons | | | Old persons | | | Difference |
|---|---|---|---|---|---|---|---|
| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Ramal height .. | With teeth | | | | | | |
| | 100 | $63.71 \pm 0.53$ | 5.29 | 100 | $67.15 \pm 0.53$ | 5.30 | — $3.44 \pm 0.75$ |
| | Without teeth | | | | | | |
| | 51 | $64.00 \pm 0.70$ | 4.99 | 100 | $65.64 \pm 0.57$ | 5.66 | — $1.64 \pm 0.90$ |
| Base length | With teeth | | | | | | |
| | 100 | $81.21 \pm 0.40$ | 4.60 | 100 | $79.35 \pm 0.52$ | 5.24 | + $1.86 \pm 0.69$ |
| | Without teeth | | | | | | |
| | 51 | $77.86 \pm 0.82$ | 5.81 | 100 | $78.36 \pm 0.49$ | 4.93 | — $0.50 \pm 0.96$ |
| Angle of lower jaw | With teeth | | | | | | |
| | 100 | $129.54 \pm 0.73$ | 7.28 | 100 | $126.00 \pm 0.70$ | 7.05 | + $3.54 \pm 1.01$ |
| | Without teeth | | | | | | |
| | 51 | $136.91 \pm 0.97$ | 6.83 | 100 | $126.67 \pm 0.74$ | 7.36 | + $10.24 \pm 1.22$ |

In return, the elderly group with teeth showed an decreased length of the base line compared with the corresponding young group. The intergroup difference is $1.86 \pm 0.69$ and it is probable. The difference, $0.50 \pm 0.96$, between the toothless groups is neither significant nor probable from a statistical point of view.

The angle of the jaw seems to decrease with age in persons with teeth, the significant difference being $3.54 \pm 0.01$ . The same feature, but more pronounced, holds for persons without teeth, in whom the decrease is $10.24 \pm 1.22$ and also statistically significant. This effect of age has probably to do with the reduced chewing pressure in old

people due to dental erosion. The greater difference in persons without teeth fits in with this theory. To be sure, most of them have dentures but that is another reason for a lower chewing pressure.

*Table 18. Means of Roentgenographic Measurements, in Sagittal Projection, on Young and old Persons with and without Teeth, and Differences between the Means for Young and Old. Reduced Measurements*

| | Young persons | | | Old persons | | | Difference |
|---|---|---|---|---|---|---|---|
| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Ramal width in dental plane | With teeth | | | | | | |
| | 100 | 32.74 ± 0.33 | 3.28 | 99 | 32.78 ± 0.36 | 3.57 | — 0.04 ± 0.49 |
| Ramal width in nasal plane.. | With teeth | | | | | | |
| | 100 | 36.60 ± 0.37 | 3.74 | 100 | 39.21 ± 0.40 | 4.00 | — 2.61 ± 0.54 |
| | Without teeth | | | | | | |
| | 51 | 31.34 ± 0.43 | 3.10 | 100 | 37.30 ± 0.47 | 4.77 | — 5.96 ± 0.64 |
| Width at jaw angle..... | With teeth | | | | | | |
| | 100 | 30.77 ± 0.34 | 3.41 | 100 | 32.47 ± 0.36 | 3.62 | — 1.70 ± 0.50 |
| | Without teeth | | | | | | |
| | 51 | 26.81 ± 0.42 | 3.06 | 100 | 30.98 ± 0.40 | 4.00 | — 4.17 ± 0.58 |

On profile pictures the ramal width in level with the rearward extension of the line joining incisal cutting edge and highest distal cusp on the left second molar was measured in old and young persons with teeth (table 18).

The ramal width seems not to change in the dental plane (the negligible, statistically insignificant difference between young and old persons with teeth is — 0.04 ± 0.49).

In young and old persons with and without teeth the ramal width was measured along the dorsal extension of the tangent through the floor of the nose. So was the width of the jaw angle along the bisect of the latter.

The ramal width in the nasal plane gives the appearance of changing with age both in those with teeth, where the significant difference is 2.61 ± 0.54, and in the toothless where the difference,

which also is significant, is $5.96 \pm 0.64$. The most likely interpretation of this finding is that the measurements are taken in different planes in the manner explained elsewhere.

The width of the jaw at the angulus is greater in old persons with teeth, the significant difference being $1.70 \pm 0.50$. In persons without teeth the width of the jaw is also greater in old persons and the significant difference is $4.17 \pm 0.58$ mm.

The ramus consequently grows broader as the age increases particularly in toothless persons. The most likely explanation would seem to be »rotation» of the type discussed previously. The increase should in conformity with this be illusory rather than true and due to the

*Table 19. Means of Roentgenographic Measurements, in Sagittal Projection, on Young and Old Persons with and without Teeth, and Differences between the Means for Young and Old. Reduced Measurements*

| | Young persons | | | Old persons | | | Difference |
|---|---|---|---|---|---|---|---|
| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Height of corpus including dental crown, along medial line.... | With teeth | | | | | | |
| | 100 | $48.96 \pm 0.41$ | 4.06 | 99 | $49.04 \pm 0.45$ | 4.49 | $-0.08 \pm 0.61$ |
| Height of corpus including dental crown, at left 2nd molar | With teeth | | | | | | |
| | 100 | $30.48 \pm 0.25$ | 2.50 | 100 | $34.22 \pm 0.34$ | 3.44 | $-3.74 \pm 0.42$ |
| Height of corpus at left 2nd molar ..... | With teeth | | | | | | |
| | 100 | $23.04 \pm 0.26$ | 2.79 | 100 | $24.87 \pm 0.36$ | 3.65 | $-1.83 \pm 0.44$ |
| | Without teeth | | | | | | |
| | 100 | $17.67 \pm 0.45$ | 3.16 | 100 | $19.30 \pm 0.36$ | 3.63 | $-1.63 \pm 0.58$ |
| Height of corpus along medial line ..... | With teeth | | | | | | |
| | 94 | $33.61 \pm 0.20$ | 2.77 | 100 | $33.97 \pm 0.32$ | 3.25 | $-0.36 \pm 0.43$ |
| | Without teeth | | | | | | |
| | 51 | $29.54 \pm 0.47$ | 3.36 | 100 | $25.65 \pm 0.53$ | 5.24 | $+3.89 \pm 0.71$ |

larger angle of the jaw in old persons. Of course, this interpretation is not certain but it should be borne in mind.

With regard to the height of the corpus at the 2nd molar, including its highest cusp, it is greatest in old persons with teeth the significant difference being $3.74 \pm 0.42$ (table 19). In order to estimate the extent to which this difference is due to emergence of the teeth from their alveolar sockets, the height of the jaw was also measured up to the marginal ridge. In this case too old persons showed the greatest height, the significant difference being $1.83 \pm 0.44$. It will be seen that these difference are to each other approximately as 2 is to 1. Consequently it may be said that about half the increase shown by old persons may be attributed to the emergence of the tooth from the alveolar ridge. In toothless persons the corpus in this region seems to be somewhat enlarged in the old persons, the difference is $1.63 \pm 0.58$ which is probable but might be due to random variation.

Along the medial line the difference between the height of the corpus in young and in old persons with teeth is not statistically significant and amounts to $0.36 \pm 0.43$. In the toothless persons, on the other hand, the young have a higher corpus height than the old, the significant difference being $3.89 \pm 0.71$ and probably due to age atrophy.

*Table 20. Means of the Total Mandible Surface and Corpus Surface on Profile Roentgenographs of Young and Old Persons with and without Teeth in cm², and Differences between the Means for Young and Old*

| | Young persons | | | Old persons | | | Difference |
|---|---|---|---|---|---|---|---|
| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Total surface area of lower jaw ..... | With teeth | | | | | | |
| | 97 | 34.99 ± 0.33 | 3.29 | 100 | 37.50 ± 0.51 | 5.18 | — 2.51 ± 0.61 |
| | Without teeth | | | | | | |
| | 51 | 31.29 ± 0.48 | 3.45 | 100 | 33.20 ± 0.42 | 4.23 | — 1.90 ± 0.64 |
| Total surface area of corpus | With teeth | | | | | | |
| | 97 | 20.22 ± 0.21 | 2.07 | 100 | 20.76 ± 0.26 | 2.62 | — 0.54 ± 0.34 |
| | Without teeth | | | | | | |
| | 51 | 16.76 ± 0.33 | 2.39 | 100 | 17.27 ± 0.29 | 2.90 | — 0.51 ± 0.44 |

The mandibular surface as seen on profile pictures of persons with teeth (table 20) increases in area with age. The difference, $2.51 \pm 0.61$, is significant. Also in persons without teeth the surface area increases, but not quite as much. The difference is $1.90 \pm 0.64$ and is significant. The increased surface area is probably due to a lengthening of the base line, as demonstrated in chapter III.

The surface of corpus mandibulae also seems to increase as time passes. When teeth are present the difference is $0.54 \pm 0.44$, and when they are absent it is $0.51 \pm 0.44$. As neither of these differences is significant or even probable it would be unsafe to draw any definite conclusions from the size relationships between the surfaces of ramus and corpus.

This circumstance in turn suggests that the enlargement of the total mandibular surface area is localized to the ramus and due to the previously mentioned »rotation».

### *Measurements on Frontal Roentgenographs*

On the frontal pictures, just as on the profiles, old and young persons were compared, and in some respects frontal and profile pictures were compared. Similarly, measurements taken on frontal roentgenographs were sometimes compared with measurements taken directly on the patient.

*Table 21. Means of Roentgenographic measurements, in Frontal Projection on Young and Old Persons with and without Teeth and Differences between the Means for Young and Old. Reduced Measurements*

| | Young persons | | | Old persons | | | Difference |
|---|---|---|---|---|---|---|---|
| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Incisal edge — gnathion | With teeth | | | | | | |
| | 100 | 40.17 ± 0.28 | 2.74 | 100 | 41.38 ± 0.32 | 3.20 | − 1.21 ± 0.43 |
| Alveolar rim — gnathion | With teeth | | | | | | |
| | 97 | 32.21 ± 0.34 | 2.28 | 96 | 30.64 ± 0.31 | 3.06 | + 1.57 ± 0.46 |
| | Without teeth | | | | | | |
| | 51 | 29.80 ± 0.63 | 4.49 | 99 | 24.63 ± 0.47 | 4.74 | + 5.17 ± 0.79 |

Comparing first the measurements for the height (table 21) of the jaw along the medial line including teeth, we find a difference that is on the verge of being significant, $1.21 \pm 0.43$, i.e. for old persons the measurement is greater. Considering on the other hand the same measurements without teeth, i.e. from alveolar rim to gnathion, we instead find a reduction in the group without teeth. It is very pronounced and amounts to $5.17 \pm 0.79$ and is censequently statistically significant within comfortable limits. Also in the group with teeth we observe a reduction with age that is very close to being significant, viz. $1.57 \pm 0.46$. This decrease agrees with what we noted on the profile roentgenographs and should be an expression for a progressive age atrophy. The fact that we obtained a deviation in the opposite direction in the group with teeth, where the length of the teeth was included, is nothing but an effect of the previously mentioned phenomenon: that the teeth gradually emerge out of the alveolar process. The abrasion that constantly takes place is too slow to outweigh the latter process.

*Table 22. Mean Intergonial and Intercondylar Distances on Frontal Roentgenographs in Young and Old Persons with and without Teeth and Differences between Young and Old. Reduced Measurements*

| | Young persons | | | Old persons | | | Difference |
|---|---|---|---|---|---|---|---|
| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Intergonial distance .. | | | With teeth | | | | |
| | 99 | $101.53 \pm 0.52$ | 5.17 | 100 | $106.18 \pm 0.65$ | 6.44 | $-4.65 \pm 0.83$ |
| | | | Without teeth | | | | |
| | 51 | $101.56 \pm 0.80$ | 5.68 | 100 | $103.93 \pm 0.55$ | 5.51 | $-2.37 \pm 0.97$ |
| Intercondylar distance .. | | | With teeth | | | | |
| | 99 | $119.97 \pm 0.55$ | 5.48 | 100 | $121.98 \pm 0.60$ | 6.03 | $-2.01 \pm 0.81$ |
| | | | Without teeth | | | | |
| | 51 | $119.27 \pm 0.73$ | 5.21 | 100 | $121.94 \pm 0.58$ | 5.79 | $-2.67 \pm 0.93$ |

The distance between the two external points on the angles of the jaw increases with advancing age (table 22), both for persons with teeth and for those without teeth. When teeth are present the differ-

ence is $4.65 \pm 0.83$ and statistically significant. When teeth are absent it is somewhat smaller, $2.37 \pm 0.97$ and not significant but statistically probable.

Here also we find agreement with the measurements taken directly on the patients, in so far as the direct intergonial distance increases both in patients without and in persons with teeth.

The extreme intercondylar distance, furthermore, increases with advancing age irrespective of whether or not teeth are present. The differences are $2.01 \pm 0.81$ and $2.67 \pm 0.93$ and both are statistically probable. In this case as well, therefore, the roentgenographic measurements agree with the previously verified direct measurements, although the differences between the latter were significant. We have pointed out once before that the obtained differences might be due to an increase with advancing age in the thickness of the soft tissues. If this is so, the obtained difference would be due to random variation, which still is possible. A true increase in the soft tissues seems hardly credible, but cannot be definitely ruled out on the basis of the results just discussed.

The width of ramus ascendens (table 23) measured in level with the floor of care of the nose shows no significant difference between young and old persons. On the left side the group with teeth

*Table 23. Mean Ramal Width on Frontal Roentgenographs in Nasal Plane in Young and Old Persons with and without Teeth and Differences between Young and Old. Reduced Values*

| | Young persons | | | Old persons | | | Difference |
|---|---|---|---|---|---|---|---|
| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | |
| | With teeth | | | | | | |
| Left ramus .. | 100 | $11.00 \pm 0.20$ | 1.95 | 100 | $11.82 \pm 0.22$ | 2.28 | $-0.82 \pm 0.30$ |
| | Without teeth | | | | | | |
| | 51 | $12.19 \pm 0.27$ | 1.94 | 100 | $12.64 \pm 0.22$ | 2.22 | $-0.45 \pm 0.35$ |
| | With teeth | | | | | | |
| Right ramus | 99 | $10.37 \pm 0.17$ | 1.72 | 100 | $10.26 \pm 0.24$ | 2.44 | $+0.11 \pm 0.29$ |
| | Without teeth | | | | | | |
| | 51 | $11.44 \pm 0.26$ | 1.89 | 100 | $11.71 \pm 0.21$ | 2.10 | $-0.27 \pm 0.33$ |

have a probable difference of 0.82 ± 0.30 between young and old persons. The other differences in this region are not even anywhere near statistically probable and therefore provide no evidence indicating changes in the width of the jaw with advancing age.

*Table 24. Differences between Measurements along Medial Line from Incisal Edge to Gnathion in Persons with Teeth and from Alveolar Margin to Gnathion in Edentulous Persons*

| | Old persons with teeth | | | Old persons without teeth | | | Difference with without |
|---|---|---|---|---|---|---|---|
| | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | $N$ | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Measurements (reduced) on frontals .... | 100 | 41.38 ± 0.32 | 3.20 | 99 | 24.63 ± 0.47 | 4.74 | + 16.75 ± 0.57 |
| Measurements, direct, on the patient .... | 99 | 48.08 ± 0.37 | 3.68 | 96 | 31.45 ± 0.48 | 4.70 | + 16.63 ± 0.61 |
| | Young persons with teeth | | | Young persons without teeth | | | |
| Measurements (reduced) on frontals .... | 100 | 40.17 ± 0.28 | 2.74 | 51 | 29.80 ± 0.63 | 4.49 | + 10.37 ± 0.69 |
| Measurements, direct, on the patient .... | 99 | 45.58 ± 0.26 | 2.61 | 50 | 34.08 ± 0.54 | 3.80 | + 11.50 ± 0.60 |

In order to evaluate to what extent the teeth are responsible for any or part of the differences in regard to the height of the median line of the jaws, we compared old persons with teeth and old persons without teeth. The difference due to the teeth turned out to be 16.65 ± 0.57. Table 24 shows that the corresponding, directly measured difference is 16.63 ± 0.61. The agreement is excellent, which indicates that the measurements were exact. We compared young persons similarly and found a roentgenographic difference of 10.37 ± 0.69 and a direct difference of 11.50 ± 0.60. Here also the two types of measurements agree nicely. It would now be interesting to know whether the part of the measurements due to the teeth is greater in old than in young persons, as that would be a direct measurement of dental eruption from the alveolar sockets. Such protrusion seems to be about half the height of the teeth.

*In the preceding section we found the following*

The results obtained can be summarized by means of fig. 31, 32, 33 and 34. They are so made that the picture of a young person is superimposed on that of an old person with an about equivalent set of teeth. In the composite profile picture the base lines and the angles coincide. In the composite frontal picture the median plane and the gnathion coincide. We find the following:

*Comparison between profil roentgenograms of old and young persons with teeth. Base line and Angulus are Common*

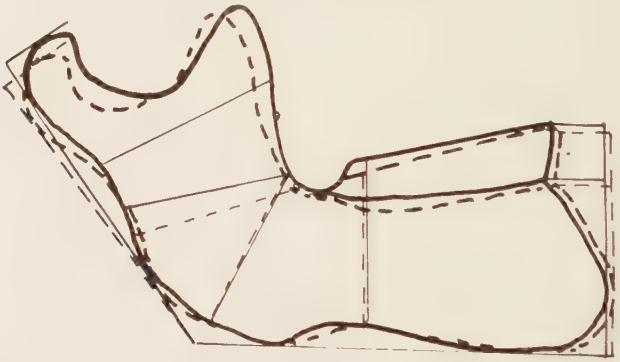


*Fig. 31. Old person with teeth* ————
*Young person with teeth* — — — —

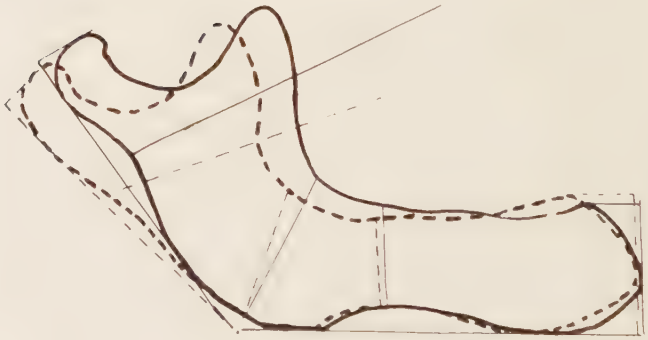


*Fig. 32. Old person with teeth* ————
*Young person without teeth*— — — —

When old and young persons are compared in sagittal roentgenographs (fig. 31, 32) it turns out that the ramal width in the nasal plane in old persons has increased, particularly in patients without teeth. These difference exist in the groups with as well as in those without teeth.

Also at the juncture of ramus and corpus mandibulare the width increases in the sagittal pictures of old persons, the difference being greatest in the groups without teeth.

In the region of the second molar the height of the jaw is significantly greater in old persons, but the difference is much more marked when teeth are present, irrespective of whether the height be measured from the cutting edge or from the alveolar margin. Half the increase is derived from dental protrusion from the alveolar socket and half from mandibular growth. The patients without teeth, too, show a small but none the less significant increase.

Along the medial line, on the other hand, the sagittal picture reveals dissimilarities between groups with and groups without teeth. The groups with teeth are not significantly different, but in the groups without teeth there is a difference between young and old. In the latter the height is about one eighth shorter, which is safely significant from a statistical aspect.

By comparing the groups with and without teeth one gets the impression that the non-reduction of the mandibular height along the medial line in old persons with teeth is due to a protrusion of the teeth from their sockets to about half the coronal height.

Moreover, in old persons the length of the body of the lower jaw seems to have decreased, the measured decrease being statistically probable.

The angle of the jaw in old persons with teeth compared to young shows a moderate reduction by about 3.5°. In the anodontic groups the old persons have practically the same mandibular angle as those with teeth, while the angle in edentulous young men is considerably larger than in young men with teeth. The latter difference is just over 10°. Most of the angular difference between young and old persons without teeth is probably caused by projection of the jaw following altered occlusal conditions and by the greater resilence of the bony structure in young men as compared to old.

*Comparison between frontal roentgenographs of old and young person with teeth. Medial line and gnathion are common.*

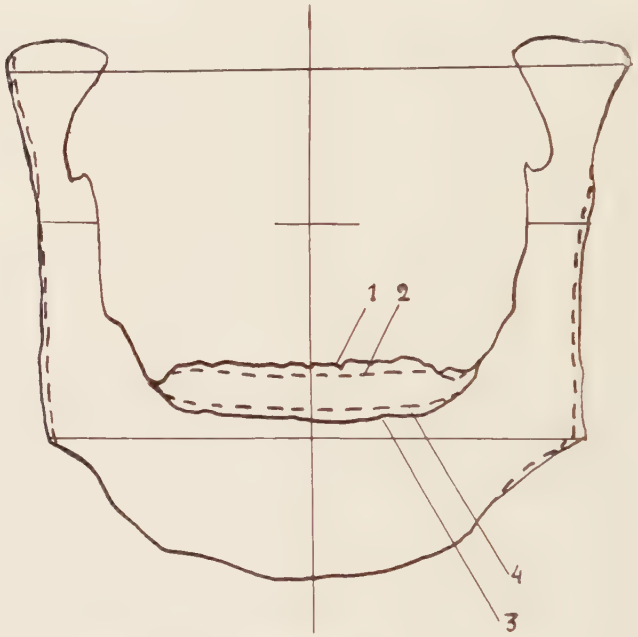



*Fig. 33. Old person with teeth* ————
*Young person with teeth* — — —
*1 and 2. Incisal cutting edge*
*3 and 4. Alveolar ridge*

The surface of the mandible shows a considerable increase in old persons, most of the excess being confined to ramus ascendens.

The frontal roentgenographs (fig. 33, 34) reveal in the group of old men with teeth compared to young men with teeth a statistically significant increase of the height along the medial line of corpus mandibulare, irrespective of whether the measurement is taken from the incisal edge or from the alveolar margin.

In persons without teeth, on the other hand, the latter measurement has decreased significantly in old persons. The roentgenographic measurements are in both cases borne out by the direct measurements.

The frontal wiews show, furthermore, that the distance between the outer and inner angles of the jaw increases with age, the difference being significant for both toothless jaws and jaws with teeth. These measurements, too, are borne out by significant direct measurement.

The ramal width in frontal roentgenographs showed no significant differences between young and old persons, but a slight increase with age is probable.

Similarly, the distance between the lateral limitations of the condyles seems to increase with advancing age. The differences are statistically probable. This is borne out by the direct measurements, although the latter difference is significant, but that might be due to the soft tissues.

The negative results which we have obtained is contrary to generally held opinions. The general view is, as noted at the beginning of the book, that the mandible atrophies seriously as the years go

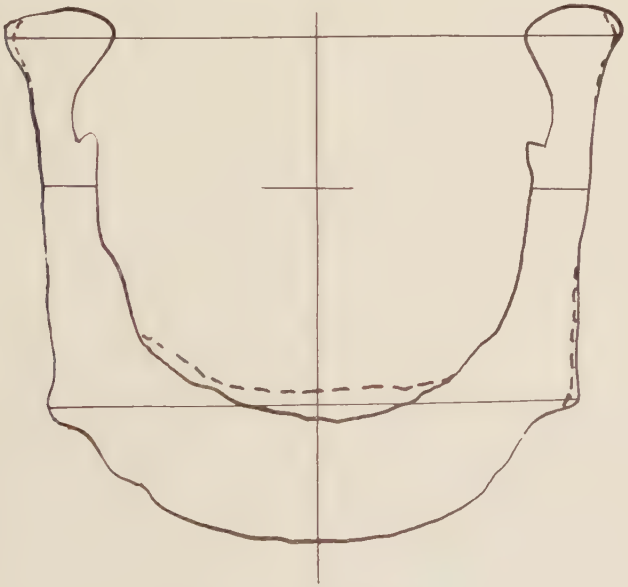


*Fig. 34. Old person without teeth* ————
*Young person without teeth* — — — —

by, which precept we have been unable to verify. Perhaps the main background for this misconception is that the mucosa does atrophy. With regard to the bone, we have at any rate found no marked degree of atrophy. In point of fact, it may be possible that as time goes by a small amount of new bony tissue is formed, which might be the reason why the teeth are pushed out of their alveolar sockets and which in edentulous persons might give rise to a regeneration of bone and so to some extent cancel out any atrophy that might occur. It may be mentioned, moreover, that our results do not rule out the possibility that atrophy takes place at still higher age levels. It is perhaps unnecessary to mention that our test persons were in part selected, in so far as some of them still have teeth and others do not. If such a selective process is important, the discrepancy between the two groups ought to be greater than the one we have found.

## SUMMARY

The aim of the present investigation is to ascertain whether the mandible in old and young persons undergoes any changes in size following a loss of teeth. Moreover, to what extent age changes can be observed in persons with teeth and in persons without teeth.

With this in view a series of 351 test persons was assembled. The series was made up of a group of young persons with a mean age of 24 years, 100 of them with teeth and 51 without teeth, and a group of 200 old persons, 100 with and 100 without teeth, whose mean age was 72 years.

These test persons were roentgenographed with the beam set in two directions at right angles to one another, partly dorsofrontal projection, and partly lateral projection. A cephalometric appliance was adapted to facilitate the photographic procedure.

The roentgenographs obtained thus were measured and, for the sake of comparison, some corresponding measurements were taken directly on the test persons.

*The following results were obtained with regard to mandibular changes following a loss of teeth.*

1. In young persons the angle of the jaw (angulus) is greater in those without teeth than in those who have teeth (difference: $7.37 \pm 1.21$ ). No similar changes seem to take place in old persons after a total loss of teeth.

2. Compared to young persons with teeth, the base length in young persons without teeth shows a significant decrease. However, though it is not proved, this decrease might be secondary to

the change of the jaw angle. The total surface area of the mandible in profile views shows a slight diminution after loss of teeth in both old and young men. For the most part this change seems to involve the ramal region. The author discusses the possibility that alterations of the measuring reference points gives rise to an illusory reduction of the ramal width and surface. It seems most unlikely that the reduction is real. Besides, the distance between the external angles of the jaw and the intercondylar distance show no significant changes following loss of teeth.

3. The height of the profile of the mandible including teeth is, of course, greater than when teeth are absent. In elderly persons the difference between these levels along the medial line is $8.32 \pm 0.62$ mm and at the 2nd molar $5.57 \pm 0.51$ mm. This difference between persons who have lost their teeth and persons who still have them is less pronounced in young individuals, viz. along the medial line $4.07 \pm 0.55$ and at the 2nd molar $5.31 \pm 0.52$ mm. The unequal differences in height between young and old persons probably depend on a pushing up of the teeth, the incisors especially, from their alveolar sockets, which process in part has counteracted increased abrasion down the years. The increase must be attributed to the expression of the tooth from the alveolar ridge. The increasing abrasion as the years go by is not great enough to cancel this displacement.

*The following results were obtained with regard to age changes*

1. The angle of the lower jaw decreases as the age increases. In persons with teeth the difference is $3.54 \pm 1.01$ and in persons without teeth $10.24 \pm 1.22°$.

2. The ramal height measured along the dorsal tangent from capitulum to base line seems to increase (diff.: $3.44 \pm 0.75$ mm) as the age increases in persons with teeth.

3. The length of the base line shows no significant change with age in edentulous persons. A probable shortening of the base line with age in persons with teeth can be attributed to a frontal displacement of the dorsal reference point owing to the increase of the jaw angle.

4. The sagittal width of the ramus in level with the floor of the nose seems to increase with age in persons with and in persons without teeth. The increase may be illusory and due to positional changes of the ramus, perhaps between ramus and corpus, which problem is discussed. For in level with the occlusal plane of the lower jaw there seems to be no dissimilarity between old and young persons with teeth.

In the juncture between ramus and corpus along the bisector of the external jaw angle the width increases with age in both groups. The difference for edentulous persons is $4.17 \pm 0.58$ mm and for persons with teeth $1.70 \pm 0.50$.

5. At the 2nd molar there is a probable increase of the jaw height with increasing age in toothless persons, the difference being $1.63 \pm 0.58$.

In persons with teeth the height of the jaw was measured, and for the sake of comparison so was the same distance including the tooth to its highest cusp. It was found thereby partly that the height of the jaw increases with age (diff.: $1.83 \pm 0.44$), partly that the tooth projects farther from the jaw with increasing age (diff.: $3.74 \pm 0.42$), partly that the projection of the tooth and the increase of jaw height are approximately as large.

Similar measurements were taken along the medial line, partly to the bony rim, partly to the cutting edge of the medial incisor. The decrease of the jaw height with age on frontal roentgenographs is $1.57 \pm 0.46$ and by direct measurement the decrease is confirmed (diff.: $2.63 \pm 0.72$).

On the other hand, if the measurement is taken along the medial line from the cutting edge of the tooth to the lower edge of the mandible it increases with age. By direct measurement the difference is significant ($2.50 \pm 0.45$ mm), and the frontal roentgenograph seems to suggest the same tendency with a probable difference of $1.21 \pm 0.43$.

In the toothless persons the height of the jaw along the medial line decreases both on profile roentgenographs (diff.: $3.89 \pm 0.71$) and on frontal roentgenograhps (diff.: $5.17 \pm 0.79$), as well as by direct measurement (diff.: $2.63 \pm 0.72$).

6. The surface area of the mandible in profile between capitulum and pogonion increases with age both in persons with teeth (diff.: $2.51 \pm 0.61$ $cm^2$) and in toothless persons (diff.: $1.90 \pm 0.64$ $cm^2$).

7. If the surface measurement is limited to the corpus of the mandible some difference will be found, which would suggest that old persons have a slightly larger corpus surface than young, the difference being about the same in toothless persons and in persons with teeth. However, the differences are not significant, and consequently it must be assumed that the considerable difference under 6. between the total surfaces of the jaw mainly is due to the ramus.

8. On frontal roentgenographs the distance between the external angles of the jaw increased with age in both persons with teeth (diff.: $4.65 \pm 0.83$) and edentulous persons (diff.: $2.37 \pm 0.97$), which was confirmed by the direct measurements (diff.: $5.46 \pm 0.77$ and $3.64 \pm 0.92$, respectively).

9. The distance between the extreme lateral points on the condyles increased statistically by direct measurement in persons with teeth (diff.: $7.44 \pm 0.88$) and in edentulous persons (diff.: $6.90 \pm 0.99$). On the frontal roentgenographs the corresponding differences showed the same tendency, being $2.01 \pm 0.81$ and $2.67 \pm 0.93$.

# Appendix I, Primary Tables

## Changes in Toothless Jaws

I. Measurements on old persons with and without teeth, and measurements on young persons with and without teeth with differences, means and degrees of enlargement.

1. Direct measurements
2. Measurements on indicators
3. Measurements on profile roentgenographs
4. Measurements on frontal roentgenographs

## Age changes

II. Measurements in different age classes of persons with and persons without teeth, with differences, means and degrees of enlargement.

1. Direct measurements
2. Measurements on indicators
3. Measurements on profile roentgenographs
4. Measurements on frontal roentgenographs

## I. Changes in Toothless Jaws

*Measurements on old persons with and without teeth, and measurements on young per*

*Table I: 1 Direct measurements*

| Measurements directly on the patient | Old persons with teeth | | | Old persons without teet | | |
|---|---|---|---|---|---|---|
| | No. | $M \pm \varepsilon (M)$ | $\sigma$ | No. | $M \pm \varepsilon (M)$ | |
| Crista alveolaris—gnathion, along medial line | 99 | 45.[illegible] ± 0.37 | 3.68 | 96 | 31.35 ± 0.[illegible] | 4. |
| Angulus lateralis sin.—angulus lateralis dext. | 99 | 112.28 ± 0.62 | 6.21 | 96 | 110.[illegible]4 ± 0.5[illegible] | 5. |
| Condylus lateralis sin.—condylus lateralis dext. | 100 | 138.95 ± 0.59 | 5.86 | 96 | 138.10 ± 0.[illegible] | 6. |

*Table I: 2 Measurements on indicators on profil roentgenographs*

| Position of the indicator | Old persons with teeth | | | Old persons without teet | | |
|---|---|---|---|---|---|---|
| | No. | $M \pm \varepsilon (M)$ | $\sigma$ | No. | $M \pm \varepsilon (M)$ | |
| Indicator fastened behind mandible on left side | 98 | 21.020 ± 0.049 | 0.484 | 92 | 21.02[illegible] ± 0.[illegible] | 0. |
| Magnification in % | | 5.1 | | | 5.1 | |
| Indicator fastened behind mandible on right side | 96 | 22.813 ± 0.[illegible] | 0.[illegible] | 96 | 22.[illegible] ± 0.[illegible] | 0. |
| Indicator fastened on ridge of nose | 95 | 22.000 ± 0.037 | 0.363 | 94 | 22.090 ± 0.046 | 0. |
| Magnification in % | | 10 | | | 10.5 | |

*and without teeth, with differences, means and degrees of enlargement.*

| Difference th—without | Young persons with teeth | | | Young persons without teeth | | | Difference with—without |
|---|---|---|---|---|---|---|---|
| $D \pm \varepsilon(D)$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | $D \pm \varepsilon(D)$ |
| 6.63 ± 0.61 | 99 | 45.58 ± 0.26 | 2.61 | 50 | 34.08 ± 0.54 | 3.80 | + 11.50 ± 0.60 |
| 1.94 ± 0.86 | 99 | 106.82 ± 0.45 | 4.48 | 50 | 106.70 ± 0.70 | 4.97 | + 0.12 ± 0.83 |
| 0.85 ± 0.86 | 99 | 131.51 ± 0.57 | 5.63 | 50 | 131.20 ± 0.77 | 5.46 | + 0.31 ± 0.96 |

| Difference th—without | Young persons with teeth | | | Young persons without teeth | | | Difference with—without |
|---|---|---|---|---|---|---|---|
| $D \pm \varepsilon(D)$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | $D \pm \varepsilon(D)$ |
| .007 ± 0.075 | 95 | 20.968 ± 0.052<br>4.8 | 0.507 | 51 | 20.833 ± 0.087<br>4.2 | 0.625 | + 0.135 ± 0.101 |
| .058 ± 0.112 | 96 | 22.589 ± 0.067 | 0.654 | 51 | 22.412 ± 0.079 | 0.565 | + 0.177 ± 0.104 |
| .090 ± 0.059 | 89 | 21.933 ± 0.055<br>9.7 | 0.515 | 51 | 21.961 ± 0.066<br>9.8 | 0.473 | — 0.028 ± 0.086 |

*Table I: 3 Measurements on profile roentgenographs*

| Measurements on profile roentgenographs | Old persons with teeth | | | Old persons without te | | |
|---|---|---|---|---|---|---|
| | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | |
| Ramal width in level with backward extension of tangent to floor of nose | 100 | 41.32 ± 0.42 | 4.21 | 100 | 39.32 ± 0.50 | 5 |
| *Magnification* in % | | 5.1 | | | 5.1 | |
| Base line of lower jaw from dorsal tangent to ramus to perpendicular tangent through pogonion | 100 | 85.83 ± 0.56 | 5.60 | 100 | 84.98 ± 0.53 | 5 |
| *Magnification* in % | | 7.6 | | | 7.8 | |
| Tangent to dorsal margin of ramus from base line to perpendicular through superior condylar edge | 100 | 70.76 ± 0.56 | 5.59 | 100 | 69.19 ± 0.60 | 5 |
| *Magnification* in % | | 5.1 | | | 5.1 | |
| Angle between ramal tangent and base line | 100 | 126.00 ± 0.70 | 7.05 | 100 | 126.67 ± 0.74 | 7 |
| Height of corpus, measured along a perpendicular 5 cm distally of mesial reference point on base line in anodontics, or through highest 2nd premolar cusp in persons teeth | 100 | 20.00 ± 0.39 | 3.94 | 100 | 20.93 ± 0.39 | 3 |
| *Magnification* in % | | 7.6 | | | 7.8 | |
| Height of corpus at jaw angle, measured along bisector of same | 100 | 36.08 ± 0.40 | 4.02 | 100 | 34.60 ± 0.45 | 4 |
| *Magnification* in % | | 10 | | | 10.5 | |
| Total surface area of mandible | 100 | 41.07 ± 0.57 | 5.75 | 100 | 37.07 ± 0.47 | 4 |
| *Magnification* in % | | 10 | | | 10.5 | |
| Area of corpus from pogonion to jaw angle | 100 | 23.07 ± 0.29 | 2.91 | 100 | 19.29 ± 0.32 | 3 |
| *Magnification* in % | | 10 | | | 10.5 | |
| Height of corpus along medial line | 100 | 37.37 ± 0.35 | 3.57 | 100 | 28.33 ± 0.56 | 5 |
| *Magnification* in % | | 10 | | | 10.5 | |

| ifference —without | Young persons with teeth | | | Young persons without teeth | | | Difference with—without |
|---|---|---|---|---|---|---|---|
| $\pm \varepsilon (D)$ | No. | $M \pm \varepsilon (M)$ | $\sigma$ | No. | $M \pm \varepsilon (M)$ | $\sigma$ | $D \pm \varepsilon (D)$ |
| .00 ± 0.65 | 100 | 38.40 ± 0.37<br>4.8 | 3.93 | 51 | 32.70 ± 0.45<br>4.2 | 3.23 | + 5.76 ± 0.60 |
| 0.95 ± 0.77 | 100 | 87.50 ± 0.50<br>7.3 | 4.9 | 51 | 83.71 ± 0.88<br>7.0 | 6.25 | + 3.85 ± 1.00 |
| 1.85 ± 0.81 | 100 | 66.95 ± 0.56<br>4.8 | 5.56 | 51 | 66.78 ± 0.73<br>4.2 | 5.21 | + 0.17 ± 0.92 |
| 0.07 ± 1.02 | 100 | 129.28 ± 0.71<br>7.2 | 7.25 | 51 | 136.91 ± 0.97<br>6.8 | 6.85 | - 7.37 ± 1.21 |
| 5.07 ± 0.85 | 100 | 24.77 ± 0.28<br>7.1 | 2.81 | 51 | 19.00 ± 0.48<br>7.0 | 3.40 | + 5.77 ± 0.56 |
| 1.48 ± 0.60 | 100 | 34.06 ± 0.18<br>9.7 | 1.78 | 51 | 29.84 ± 0.47<br>9.8 | 3.30 | 4.22 ± 0.66 |
| 4.50 ± 0.70 | 97 | 38.74 ± 0.47<br>9.7 | 3.64 | 51 | 34.69 ± 0.<br>9.8 | 3.33 | 4.05 ± 0.68 |
| 3.78 ± 0.34 | 97 | 22.39 ± 0.23<br>9.7 | 2.29 | 51 | 18.58 ± 0.37<br>9.8 | 2.63 | 3.81 ± 0.41 |
| 9.04 ± 0.66 | 94 | 36.86 ± 0.31<br>9.7 | 2.98 | 51 | 32.44 ± 0.51<br>9.8 | 3.68 | 4.42 ± 0.61 |

*Table I: 4 Measuremnt on frontal roentgenographs*

| Measurements on frontal roentgenographs | Old persons with teeth | | | Old persons without | | |
|---|---|---|---|---|---|---|
| | No. | $M \pm \varepsilon (M)$ | $\sigma$ | No. | $M \pm \varepsilon (M)$ | |
| From alveolar ridge to gnathion, along medial line | 96 | 33.14 ± 0.34 | 3.31 | 99 | 25.96 ± 0.50 | 5 |
| *Magnification in* % | | 5.1 | | | 5.1 | |
| From angulus lateralis sin. to angulus lateralis dext. | 100 | 114.85 ± 0.70 | 6.97 | 100 | 112.71 ± 0.60 | 5 |
| *Magnification in* % | | 7.6 | | | 7.8 | |
| Ramus sinister, including both processus condyloidens and processus muscularis, in level with bottom of aperta piriformis | 100 | 13.13 ± 0.25 | 2.53 | 100 | 14.11 ± 0.25 | 2 |
| *Magnification* in % | | 10 | | | 10.5 | |
| Ramus dexter, including both processus condyloidens and processus muscularis, in level with bottom of apertura piriformis | 100 | 11.40 ± 0.27 | 2.71 | 100 | 13.08 ± 0.23 | 2 |
| *Magnification* in % | | 10 | | | 10.4 | |
| Distance from lateral part of condylus sinister to lateral part of condylus dexter | 100 | 135.53 ± 0.67 | 6.70 | 100 | 136.17 ± 0.65 | 6 |
| *Magnification* in % | | 10 | | | 10.5 | |

| Difference h -without | Young persons with teeth | | | Young persons without teeth | | | Difference with -without |
|---|---|---|---|---|---|---|---|
| $D \pm \varepsilon(D)$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | $D \pm \varepsilon(D)$ |
| 7.18 ± 0.60 | 97 | 34.62 ± 0.36<br>4.8 | 3.52 | 51 | 31.09 ± 0.66<br>4.2 | 4.69 | + 3.53 ± 0.75 |
| 2.14 ± 0.92 | 99 | 109.47 ± 0.56<br>7.3 | 5.57 | 51 | 109.19 ± 0.86<br>7.0 | 6.11 | + 0.28 ± 1.03 |
| 0.98 ± 0.35 | 100 | 12.18 ± 0.22<br>9.7 | 2.16 | 51 | 13.51 ± 0.30<br>9.8 | 2.15 | — 1.33 ± 0.37 |
| 1.68 ± 0.35 | 100 | 11.48 ± 0.19<br>9.7 | 1.90 | 51 | 12.68 ± 0.29<br>9.8 | 2.10 | — 1.20 ± 0.35 |
| 0.64 ± 0.93 | 99 | 132.81 ± 0.61<br>9.7 | 6.07 | 51 | 132.24 ± 0.81<br>9.8 | 5.78 | + 0.57 ± 1.01 |

## II. Age changes.

*Measurements in different age classes of persons with and persons without teeth, d*

*Table II: 1 Direct measurements*

| Measurements on patients directly | Old persons without teeth | | | Young persons without teeth | | | Diff. old-youn |
|---|---|---|---|---|---|---|---|
| | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | $D \pm \varepsilon(D$ |
| From crista alveolaris to gnathion, along medial line | 96 | 31.45 ± 0.48 | 4.70 | 50 | 34.08 ± 0.54 | 3.80 | — 2.63 ± |
| From angulus lateralis sin. to angulus lateralis dext. | 96 | 110.34 ± 0.59 | 5.74 | 50 | 106.70 ± 0.70 | 4.97 | + 3.64 ± |
| From condylus lateralis sin. to condylus lateralis dext. | 96 | 138.10 ± 0.63 | 6.12 | 50 | 131.20 ± 0.77 | 5.46 | + 6.90 ± |

*Table II: 2. Measurements on indicators in profile roentgenographs*

| Position of the indicator | Old persons without teeth | | | Young persons without tee | | |
|---|---|---|---|---|---|---|
| | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | |
| Indicator fastened behind ramus mand. on left side | 92 | 21.027 ± 0.057 | 0.549 | 51 | 20.833 ± 0.087 | 0. |
| Magnification in % | | 5.1 | | | 4.2 | |
| Indicator fastened behind ramus mand. on right side | 96 | 22.755 ± 0.095 | 0.927 | 51 | 22.412 ± 0.079 | 0. |
| Indicator fastened on ridge of nose | 94 | 22.090 ± 0.046 | 0.449 | 51 | 21.961 ± 0.066 | 0. |
| Magnification in % | | 10.5 | | | 9.8 | |

*s, means and degrees of enlargement.*

| asurements on patients directly | Old persons with teeth | | | Young persons with teeth | | | Dift. old-young |
|---|---|---|---|---|---|---|---|
| | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | $D \pm \varepsilon(D)$ |
| tance from incisal cutting edge along medial ine to gnathion = lowest point on chin..... | 99 | 48.08 ± 0.37 | 3.68 | 99 | 45.58 ± 0.26 | 2.61 | + 2.50 ± 0.45 |
| m angulus lateralis in. to angulus lateralis lext. ..... | 99 | 112.28 ± 0.62 | 6.21 | 99 | 106.82 ± 0.45 | 4.48 | + 5.46 ± 0.77 |
| m condylus lateralis in. to condylus lateralis dext. ..... | 100 | 138.95 ± 0.59 | 5.86 | 99 | 131.51 ± 0.57 | 5.63 | + 7.44 ± 0.82 |

| Difference ld—young | Old persons with teeth | | | Young persons with teeth | | | Difference old—young |
|---|---|---|---|---|---|---|---|
| $D \pm \varepsilon(D)$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | $D \pm \varepsilon(D)$ |
| .194 ± 0.104 | 98 | 21.020 ± 0.049<br>5.1 | 0.484 | 95 | 20.968 ± 0.052<br>4.8 | 0.507 | + 0.052 ± 0.071 |
| .343 ± 0.124 | 96 | 22.813 ± 0.059 | 0.574 | 96 | 22.589 ± 0.067 | 0.654 | + 0.224 ± 0.089 |
| .129 ± 0.080 | 95 | 22.000 ± 0.037<br>10 | 0.363 | 89 | 21.933 ± 0.055<br>9.7 | 0.515 | + 0.067 ± 0.066 |

*Table II: 3 Measuremeets on profile roengenographs*

| Profile measurements | Old persons without teeth | | | Young persons without teeth | | | Diff. old-you |
|---|---|---|---|---|---|---|---|
| | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Height of corpus along medical line from alveolar ridge perpendicularly to base line... | 100 | 28.33 ± 0.56 | 3.68 | 51 | 32.44 ± 0.51 | 3.68 | — 4.11 ± |
| *Magnification* in %..... | | 10.5 | | | 0.8 | | |
| Ramal width in level with backward extension of tangentto floor of nose | 100 | 39.32 ± 0.50 | 5.03 | 51 | 32.70 ± 0.45 | 3.23 | + 6.62 ± |
| *Magnification* in %..... | | 5.1 | | | 4.2 | | |
| Lower jaw base line between intersections of dorsal tangent toramus and perpendicular tangent through pogonion | 100 | 84.98 ± 0.53 | 5.35 | 51 | 83.71 ± 0.88 | 6.25 | 1.27 ± |
| *Magnification* in %..... | | 7.8 | | | 7.0 | | |
| Tangent to dorsal margin of ramus between base line and perpendicular through upper condylar border..... | 100 | 69.19 ± 0.60 | 5.97 | 51 | 66.78 ± 0.73 | 5.21 | 2.41 ± |
| *Magnification* in %..... | | 5.1 | | | 4.2 | | |
| Angle between ramal tangent and base line..... | 100 | 126.67 ± 0.74 | 7.36 | 51 | 136.91 ± 0.97 | 6.83 | —10.24 ± |
| Height of corpus along a perpendicular to base line 5 cm distally of mesialreference point on base line..... | 100 | 20.93 ± 0.39 | 3.94 | 51 | 19.00 ± 0.48 | 3.40 | + 1.93 ± |
| *Magnification* in %..... | | 7.8 | | | 7.0 | | |
| Height of corpus at angulus along bisector of jaw angle..... | 100 | 34.60 ± 0.45 | 4.47 | 51 | 29.84 ± 0.47 | 3.39 | + 4.76 ± |
| *Magnification* in %..... | | 10.5 | | | 0.8 | | |
| Total mandibular area.. | 100 | 37.07 ± 0.47 | 4.73 | 51 | 34.69 ± 0.52 | 3.83 | + 2.38 ± |
| *Magnification in* %.... | | 10.8 | | | 0.8 | | |
| Area of corpus from pogonion to bisector of jaw angle..... | 100 | 19.29 ± 0.32 | 3.24 | 51 | 18.58 ± 0.37 | 2.65 | + 0.71 ± |
| *Magnification* in %..... | | 10.8 | | | 0.8 | | |
| Height of corpus along medial line perpendicularly to base..... | 100 | 37.37 ± 0.35 | 3.57 | 94 | 36.86 ± 0.31 | 2.98 | + 1.51 ± |
| *Magnification* in %..... | | 10 | | | 0.7 | | |

| Profile measurements | Old persons with teeth | | | Young persons with teeth | | | Diff. old-young |
|---|---|---|---|---|---|---|---|
| | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | |
| mal width in level with backward extension of angent through incisal dge and highest 2nd premolar cusp..... | 99 | 34.54 ± 0.38 | 3.76 | 100 | 34.41 ± 0.35 | 3.45 | + 0.13 ± 0.52 |
| *gnification* in %..... | | 5.1 | | | 4.8 | | |
| mal width in level with backward extension of angent to floor of nose | 100 | 41.32 ± 0.42 | 4.21 | 100 | 38.46 ± 0.39 | 3.93 | + 2.86 ± 0.57 |
| *gnification* in %..... | | 5.1 | | | 4.8 | | |
| wer jaw base line between intersections of dorsal tangent to ramus nd perpendicular tangent through pogonion | 100 | 85.83 ± 0.56 | 5.60 | 100 | 87.56 ± 0.50 | 4.96 | — 1.73 ± 0.75 |
| *gnification* in %..... | | 7.9 | | | 7.3 | | |
| ngent to dorsal margin f ramus between base ine and perpendicular hrough upper condylar border..... | 100 | 70.76 ± 0.56 | 5.59 | 100 | 66.95 ± 0.56 | 5.56 | + 3.81 ± 0.79 |
| *gnification* in %..... | | 5.1 | | | 4.8 | | |
| gle between ramal tangent and base line... | 100 | 126.00 ± 0.70 | 7.05 | 100 | 129.54 ± 0.73 | 7.28 | — 3.54 ± 1.01 |
| ight of corpus and ooth from highest 2nd premolar cusp to lower nargin, perpendicularly to base line..... | 100 | 37.02 ± 0.37 | 3.72 | 100 | 32.86 ± 0.27 | 2.70 | + 4.16 ± 0.46 |
| *gnification* in %..... | | 7.6 | | | 7.3 | | |
| ight of corpus at 2nd premolar..... | 100 | 26.90 ± 0.30 | 3.94 | 100 | 24.77 ± 0.28 | 2.81 | + 2.13 ± 0.48 |
| *gnification* in %..... | | 7.6 | | | 7.3 | | |
| ght of corpus at angulus along bisector of aw angle..... | 100 | 36.08 ± 0.40 | 4.02 | 100 | 34.06 ± 0.38 | 3.78 | + 2.02 ± 0.55 |
| *gnification* in %..... | | 10 | | | 10.5 | | |
| tal mandibular area... | 100 | 41.07 ± 0.57 | 5.75 | 97 | 38.74 ± 0.37 | 3.64 | 2.93 ± 0.68 |
| *gnification* in %..... | | 10 | | | 10.5 | | |
| ea of corpus from pogonion to bisector of aw angle..... | 100 | 23.07 ± 0.29 | 2.91 | 97 | 22.39 ± 0.23 | 2.29 | + 0.68 ± 0.37 |
| *gnification* in %..... | | 10 | | | 10.5 | | |

*Table II: 4. Measurements on frontal roentgenographs*

| Measurements on frontal roentgenographs | Old persons without teeth | | | Young persons without teeth | | | Diff. old-youn |
|---|---|---|---|---|---|---|---|
| | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | |
| Height of corpus along medial line from alveolar ridge to gnathion... | 99 | 25.96 ± 0.50 | 5.00 | 51 | 31.09 ± 0.66 | 4.69 | — 5.13 ± |
| Angulus lateralis sin. to anglulus lateralis dext. | 100 | 112.71 ± 0.60 | 5.98 | 51 | 109.19 ± 0.86 | 6.11 | + 3.52 ± |
| Ramus sinister, including processus condyloideus and processus muscularis, in level with bottom of apertura piriformis ..... | 100 | 14.11 ± 0.25 | 2.48 | 51 | 13.51 0.30 | 2.15 | + 0.60 ± |
| Ramus dexter, including processus condyloideus and processus muscularis, in level with bottom of apertura piriformis ..... | 100 | 13.08 ± 0.23 | 2.34 | 51 | 12.68 0.29 | 2.10 | + 0.40 ± |
| Distance from lateral part of condylus sin. to lateral part of condylus dext. ..... | 100 | 136.17 ± 0.65 | 6.47 | 51 | 132.24 ± 0.81 | 5.78 | + 3.93 ± |

| ısurements on frontal roentgenographs | Old persons with teeth | | | Young persons with teeth | | | Diff. old-young |
|---|---|---|---|---|---|---|---|
| | No. | $M \pm \varepsilon(M)$ | $\sigma$ | No. | $M \pm \varepsilon(M)$ | $\sigma$ | |
| isal cutting edge to nathion along medial ne | 100 | 43.60 ± 0.34 | 3.37 | 100 | 42.21 ± 0.29 | 2.88 | + 1.39 ± 0.45 |
| ght of corpus along ıedial line | 96 | 33.14 ± 0.34 | 3.31 | 97 | 34.62 ± 0.36 | 3.52 | — 1.48 ± 0.50 |
| gulus lateralis sin. to ngulus lateralis dext. | 100 | 114.85 ± 0.70 | 6.97 | 99 | 109.47 ± 0.56 | 5.57 | + 5.38 ± 0.90 |
| mus sin., incl. both rocessus condyloideus nd processus muscu-aris, in level with bot-om of apertura piri-ormis | 100 | 13.13 ± 0.25 | 2.53 | 100 | 12.18 ± 0.22 | 2.16 | + 0.95 ± 0.33 |
| mus dext., incl. both rocessus condyloideus nd processus muscu-aris, in level with bot-om of apertura piri-ormis | 100 | 11.40 ± 0.27 | 2.71 | 100 | 11.48 ± 0.19 | 1.90 | — 0.08 ± 0.33 |
| tance from lateral part f condylus sin. to lat-ral part of condylus ext. | 100 | 135.53 ± 0.67 | 6.70 | 99 | 132.81 ± 0.61 | 6.07 | + 2.72 ± 0.9 |

## LITERATURE CITED

*Backman, Gaston,* 1931: Das Wachstumsproblem. Ergebnisse der Physiologie. Band 33. München.

— 1938: Wachstumsdauer und Lebenslänge beim Menschen. Kungl. fysiograf. sällskapet i Lund förhandlingar. Band 8.

— 1938: Relatiwität des Wachstums. Kungl. fysiograf. sällskapet i Lund förhandlingar. Band 8.

*Björk, Arne,* 1947: The face in profile. Svensk Tandläkartidskrift. Band 40.

*Broadbent, B. H., 1931:* A new X-ray technique and its application to Ortodontia. Angle Orthodontist.

— 1935: Measurement of dentofacial changes in relation to the cranium. Practical Orthodontia.

*Dahlberg, Gunnar,* 1940: Statistical methods for medical and biological students. London.

*Herulf, Gustaf,* 1940: On sources of error in radiographs of canine teeth of man. Suppl. acta odontologica Scandinavica.

*Higley, L. B.,* 1936: A head Positioner for Scientific Radiograpic and photographic Purposes. Int. J. Orthodontia. Band 22.

*Higley, L. B.,* 1950: Some thoughts on Cephalometrics and anchorage. Am. Journal of Orthodontics. Band 36, H. 2.

*Hultkrantz,* 1927: Über die Zunahme der Körpergrösse in Schweden in den Jahren 1840—1926. Nova acta Regio 80 C. Scientiarum Upsaliensis.

*Laurell, Hugo,* 1932: Metallfolien und Metalltücher als Sekundärblenden. Upsala läkarförenings förhandlingar, ny följd, 37.

— 1931: Eine Metode beim Röntgenphotographieren den grösseren Teil der schädlichen Sekundärstrahlung auszuschalten. Acta Radiol., 12.

*Margolis, Herbert,* 1943: The Axial Inclination of the Mandibular Incisors. Am. Jour. Orthodontics and Oral Surg.

— 1940: Standardized X-ray cephalographies. Am. Jour. Orthodontics and Oral Surg. Band 26.

*Martin Rudolf,* 1928: Lehrbuch der Antropologie.

*Robertsson, Brailsford,* 1908: Further Remarks on the Normal Rate of Growth of an Individual, and its Biochemical Significance. Arch. Entw. mechanik. Band 26.

— 1928: The analysis of the growth of the normal white mouse into its constituent process. J. gen. Physiol. Band 8.

*Sicher, H.* och *Tandler, J.,* 1928: Anatomie für Zahnärzte.